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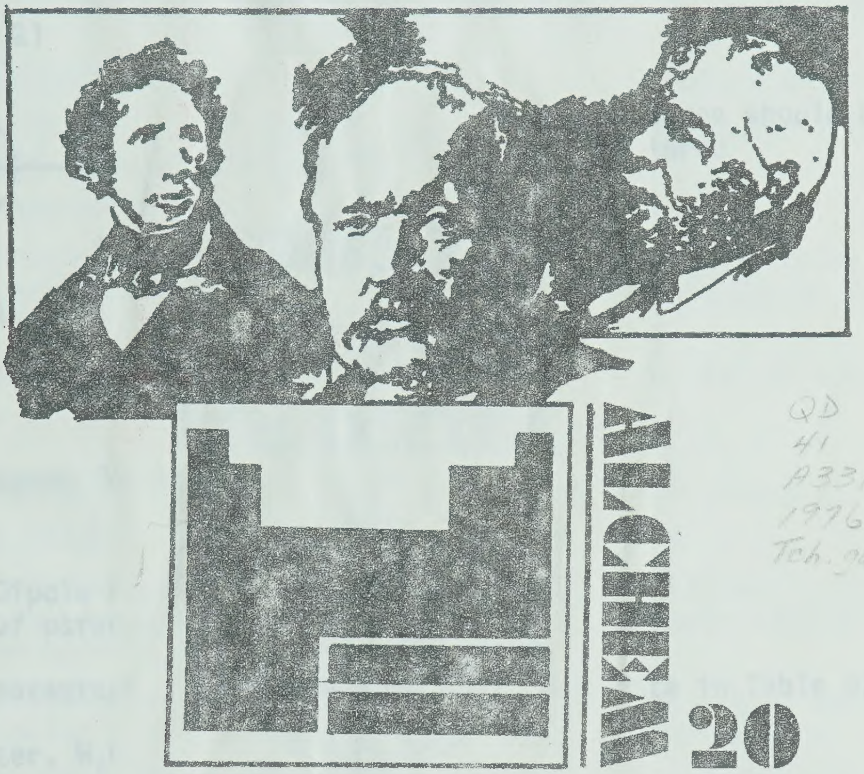

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Teachers' Guide

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TEACHERS' GUIDE

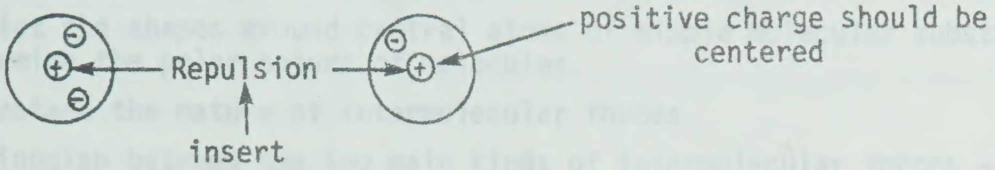
ALCHEM 20 - ERRATA

Page F15: #3 after "Note" on middle of page should read--A kilogram is slightly larger than two pounds.

PLEASE NOTE: Pages G10, G11 and G11 ARE MISPLACED. THESE THREE PAGES SHOULD FOLLOW THE FOLLOWING PARAGRAPH ON PAGE G25:

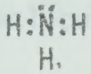
The preceding general description established the terminology and basis for predicting molecular shapes according to VSEPR Theory. The table following summarizes the fundamental aspects of VSEPR Theory as used for predicting molecular shape.

Page G1: Figure G1

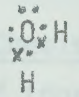


Page G10: Table G4

Lewis diagram for NH is


$H:\underset{H}{\ddot{N}}:H$

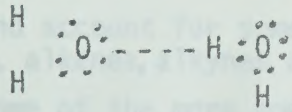
Page G23: Lewis diagram for water


$:\underset{H}{\ddot{O}}:H$

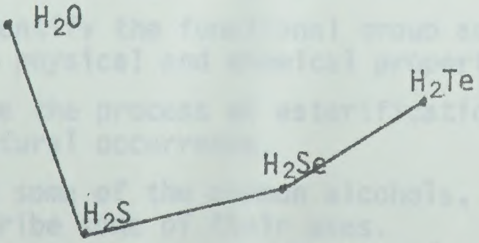
Page G30: Dipole-Dipole Forces
Bottom of paragraph (see Table G9)

Page G31: Bottom paragraph, fourth sentence: . . . the data in Table G7, . . .

Page G32: #2. water, $H_2O_{(\ell)}$


$\begin{matrix}H\\H\end{matrix}:\ddot{O}:----H:\underset{H}{\ddot{O}}:$

Page G37: Figure G17



Page G42: Should read Biography of a Chemist (not Bibliography)

Page H6: 4a.--should be 3-ethylhexane

Page H24: Part B, #6. Construct a different model of the third member of the alkene series. (Delete last part of sentence reading, "in which the double bond occurs in the middle.")

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ALCHEM 20 - OBJECTIVES

Upon completion of Unit G, Chemical Bonding, the student should be able to:

G1. understand why chemical bonding occurs.

G2. understand the interactions that are involved in chemical bonding.

G3. distinguish among covalent bonds, ionic bonds, covalent network bonds and metallic bonds.

G4. relate number of valence electrons to the kind of bonding and to bonding capacity.

G5. draw Lewis electron-dot diagrams and structural formulas of simple molecular substances.

G6. understand electronegativity and predict the polar nature of bonds.

G7. predict the shapes around central atoms of simple molecular substances, and determine the polar nature of molecules.

G8. understand the nature of intermolecular forces.

G9. distinguish between the two main kinds of intermolecular forces - van der Waal forces (including dipole-dipole forces, dipole-induced dipole forces and Londo dispersion forces) and hydrogen bonding.

G10. relate types of intermolecular forces to some properties of molecular substances.

Upon completion of Unit H, Organic Chemistry, the student should be able to:

H1. distinguish between organic and inorganic compounds.

H2. recognize hydrocarbons and distinguish between the aliphatic hydrocarbons (including alkanes, alkenes, alkynes and some of their simpler cyclic forms) and aromatic hydrocarbons.

H3. name the first ten members of the alkane, alkene and alkyne series and some of their simpler isomeric forms and name compounds of benzene.

H4. describe the characteristic bond type and shape associated with the alkanes, alkenes, alkynes and benzene.

H5. describe and account for some physical and chemical properties characteristic of alkanes, alkenes, alkynes and benzene.

H6. identify some of the more common hydrocarbons and describe some of their uses.

H7. recognize the application of such processes as fractional distillation, catalytic cracking and polymerization.

H8. name, identify the functional group and its structure and describe and account for some physical and chemical properties of some alcohols and organic acids.

H9. recognize the process of esterification and relate the product (esters) to their natural occurrence.

H10. identify some of the common alcohols, organic acids and benzene derivatives and describe some of their uses.

ALCHEM 20 - OBJECTIVES

Upon completion of Unit I, Solutions, the student should be able to:

I1. define and use the terms concentrated, dilute, solute, solvent, saturated and aqueous.

I2. do the basic moles (or mass), molarity, solution volume conversions.

I3. prepare and describe the procedure for preparing a solution of known concentration.

I4. dilute a solution to give a solution of known concentration and to do dilution calculations.

I5. define and use the terms electrolyte and nonelectrolyte and classify solutes as electrolytes and nonelectrolytes.

I6. write dissociation equations.

I7. calculate the concentration of ionic species in solution.

I8. define and use the term solubility in a qualitative and quantitative sense.

I9. do calculations relating to the quantitative definition of solubility.

I10. list the factors which affect solubility.

I11. demonstrate proficiency in the laboratory technique of pipetting.

TEACHERS' GUIDE
COMPOSITE LIST OF MATERIALS FOR ALCHEM 20

Chemicals

acetone
ammonium acetate
ammonium hydroxide
barium chloride
barium hydroxide
benzene
bromine
1-butanol
2-butanol
calcium metal
calcium hydroxide
carbon tetrachloride
chlorine gas
chromium(III) nitrate
copper(II) sulfate pentahydrate*
cyclohexane
cyclohexene
1,2-ethanediol
ethanol
formic acid
glacial acetic acid
glucose
glycerol (1,2,3-propanetriol)
hexane
hydrochloric acid
hydrogen peroxide (3%)
iodine
lead(II) acetate
lead(II) nitrate
litmus paper
methanol
nitric acid
pentanoic acid
1-pentanol
2-pentanol
3-pentanol
potassium dichromate
potassium hydroxide
potassium iodide
potassium permanganate
salicylic acid
sodium bicarbonate
sodium bromide
sodium carbonate
sodium chloride
sodium hydroxide
sodium sulfate
sucrose
stainless steel wool
steel wool
sulfuric acid
tetrachloroethane
zinc metal

* need in large quantities

Chemicals to be obtained locally as required:

household ammonia
lye
soda pop
vinegar

Equipment (Class Sets)

balances (centigram)
beakers (50 ml)
beakers (100 ml)
beakers (250 ml)
beakers (400 ml)
bunsen burners
burets (50 ml)
buret brushes
clamps (buret)
clamps (utility)
cylinders (graduated - 10 ml)
cylinders (graduated-50 ml)
cylinders (graduated-100 ml)
dropper bottles (100 ml or 4 oz)
Erlenmeyer flasks (250 ml)
evaporating dishes
funnels (standard stem, 75 mm dia.)
glass tubing (6 mm)
medicine droppers
meniscus finders
metric ruler
molecular model student kits
phenolphthalein
pipet bulbs
pipets (delivery - 10 ml)
pipets (delivery - 25 ml)
pipets (graduated 10 ml)
reagent bottles
ring support with clamp (O.D. 10 cm)
ringstand support
rubber policeman
rubber stoppers (#1, one-hole)
rubber stoppers (#00, solid)
rubber stoppers (#0, solid)
rubber stoppers (#1, solid)
rubber stoppers (#2, solid)
stirring rods
test tubes (18 x 150 mm)
test tubes (13 x 100 mm)
test tube brushes
test tube clamps
test tube racks
thermometers (Celsius)
tongs
volumetric flasks (100 ml)
wash bottles
watch glasses
wire gauze

Equipment (Demo Sets)

For Fractional Distillation Demo (See Organic Chemistry, p. H12)

Organic Chemistry Kit
variable AC power supply
heating mantle
thermometer (-10 to 250° C and ground joint)

Other Demos

Molecular model kit
photometer (optional)
multimeter or ohmmeter (optional)

TEACHERS' GUIDE

REVIEW OF CHEMISTRY 10

General Information

It is suggested that the review be divided into two parts. The first part up to and including page 10 should be done preliminary to G and H, *Chemical Bonding* and *Organic Chemistry*. The suggested time for this part of the review is 4 to 5 - forty minute periods. The remaining portion of the review should be done preliminary to the Units H and I - *Solutions* and *Reactions in Solution*. The latter part of the review will require about 6 to 8 - forty minute periods. This split of the review is recommended because the latter part of the review which is on chemical equations and stoichiometry has more direct application to Unit I, *Solutions* and Unit J, *Reactions in Solution*.

Reaction of Zinc Metal with Aqueous Lead (II) Acetate - Lab F1

1. The lab involving zinc metal and aqueous lead (II) acetate is intended to give students additional lab experience with stoichiometry. An alternative (or supplementary) lab involving sodium bicarbonate and hydrochloric acid is provided in the *Teachers' Guide*. Teachers may wish that students do either or both labs.

2. Both the given and alternate labs will require prelab explanation only in regard to the dispensing of the materials as pertaining to laboratory facilities and for demonstrating decanting before Day II of the procedure for the zinc-lead (II) acetate lab.

3. A change in the procedure of both experiments regarding the preparation of vials of lead (II) acetate or sodium bicarbonate is desirable. The students themselves should obtain the required quantity of these reagents since their advance preparation by the lab assistant is too tedious. Students can quite readily mass the required quantity of each reagent on a piece of paper.

4. It is suggested that 3.00 g of lead (II) acetate and 2.00 g of sodium bicarbonate be used.

5. For the zinc-lead (II) acetate experiment the commonly available lead (II) acetate is trihydrated, $Pb(CH_3COO)_2 \cdot 3H_2O$. Explain to the students that the water of hydration is not actively involved in the reaction but must be considered when calculating the molar mass or number of moles of the lead (II) acetate.

REVIEW OF CHEMISTRY 10

THE REACTION OF SODIUM BICARBONATE, $NaHCO_3$, WITH HYDROCHLORIC ACID, $HCl_{(aq)}$

ALTERNATE LAB F1

PURPOSE: To apply stoichiometric calculations to a reaction between sodium bicarbonate and hydrochloric acid:

$$NaHCO_3 + HCl(aq) \longrightarrow NaCl(aq) + H_2O + CO_{2\,(g)}$$

Note: $NaHCO_3$ is commonly called baking soda and HCl(aq) is sometimes called muriatic acid.

MATERIALS:

1 - centigram balance
1 - evaporating dish
1 - watch glass
1 - burner
1 - wire gauze
1 - ring stand
1 - wash bottle containing distilled water
1 - vial of $NaHCO_3$ (about 2.00 g)
1 - dropping bottle of dilute (6M) hydrochloric acid

PROCEDURE:

1. Record the number of the centigram balance. All masses are to be determined to 0.01 g.
2. Clean and dry an evaporating dish and watch glass.
3. Determine the mass of the evaporating dish and watch glass.
4. Empty the vial containing the $NaHCO_3$ into the evaporating dish.
5. Determine the mass of the evaporating dish, watch glass and $NaHCO_3$.
6. Cover the evaporating dish with the watch glass. Place the convex side of the watch glass down and slightly off centre so that the lip of the evaporating dish is uncovered.
7. Add dilute hydrochloric acid drop by drop through the lip of the evaporating dish to the $NaHCO_3$ in the dish. Continue this procedure until no more reaction occurs when a drop of the acid is added, then add several drops more. Do not add too much hydrochloric acid.
8. Carefully rinse the bottom side of the watch glass with a few ml. of H_2O and collect the washings in the evaporating dish.
9. Heat the evaporating dish and contents covered with a watch glass until the residue (NaCl) is *completely dry*. If the residue in the dish pops and spatters, reduce the flame size or move the evaporating dish higher above the flame.
10. Allow the dish to cool to room temperature then determine the mass of the evaporating dish, NaCl residue and watch glass cover.
11. Clean up your station, then do the calculations following.

REVIEW OF CHEMISTRY 10

ALTERNATE LAB F1

DATA:

Balance number. ________

Mass evaporating dish, cover and $NaHCO_3$. ________

Mass of evaporating dish and cover. ________

Mass of $NaHCO_3$. ________

Mass of evaporating dish, cover and NaCl residue. ________

Mass of evaporating dish and cover. ________

Mass of NaCl residue. ________

CALCULATIONS:

1. Calculate the moles of $NaHCO_3$ used in this experiment.

2. Calculate the moles of NaCl that were formed in this experiment.

3. How should the number of moles of $NaHCO_3$ consumed and the number of moles of NaCl produced compare? Explain.

4. Determine the mass of NaCl that should form in the reaction based on the amount of $NaHCO_3$ that was used in this reaction, i.e., determine the theoretical mass of NaCl that should form.

5. Calculate the percentage yield of NaCl.

$$\% \text{ yield} = \frac{\text{experimental mass}}{\text{theoretical mass}} \times 100\%$$

TEACHERS' GUIDE
REVIEW OF CHEMISTRY 10

Answer Key

Page F6 : Matching Exercise

1. e 2. j 3. a 4. f 5. i

6. h 7. g 8. b 9. d 10. c

1. a. metallic character decreases with increasing atomic number in a period
   b. metallic character increases with increasing atomic number in a group
2. The nuclei have increasing attraction for their valence electrons with increasing atomic number in a period.

Page F7 : Atomic Structure

1. 0, 8, 8, 0
2. F^{1-}, 9, 10, 1-
3. carbon atom, 6, 6, 0
4. chloride ion, 17, 18, 1-
5. magnesium ion, Mg^{2+}, 10
6. sulfide ion, S^{2-}, 18
7. potassium ion, K^{1+}, 19
8. neon atom, Ne, 10
9. barium ion, 56, 54, 2+
10. He, 2, 2, 0
11. hydrogen ion, 1, 0, 1+
12. nitride ion, N^{3-}, 3-
13. iron(III), (ferric), 26, 23, 3+
14. tin(IV), (stannic), 50, 46, 4+
15. Ca^{2+}, 20, 18, 2+
16. aluminum ion, 13, 10, 3+
17. copper(II), (cupric) ion, Cu^{2+},
18. iodide ion, I^{1-}, 53
19. Au, 79, 79, 0
20. cesium ion, Cs^{1+}, 55

Page F9 : Ionic Compounds

1. sodium oxide
2. $SrSO_3$
3. Ga_2S_3
4. ammonium acetate
5. $Zn(NO_3)_2$
6. nickel(III) (nickelic) bromide
7. $Mg(CH_3COO)_2$
8. nickel(III) (nickelic) sulfate
9. SnO_2
10. calcium bromide
11. $(NH_4)_2CO_3$
12. lead(II) (plumbous) sulfate
13. $FeSO_4$
14. $Zn(C\ell O_3)_2$
15. zinc oxide
16. potassium bromate
17. CuO
18. sodium bicarbonate
19. lead(IV) (plumbic) oxide
20. $CrC\ell_3$

TEACHERS' GUIDE
REVIEW OF CHEMISTRY 10

Answer Key

Page F9 : Acids

1. hydrochloric acid
2. $HBrO_{3(aq)}$
3. hydrobromic acid
4. $H_2S_{(aq)}$
5. sulfuric acid
6. $HI_{(aq)}$
7. nitric acid
8. $H_3PO_{4(aq)}$
9. chloric acid
10. $H_2CO_{3(aq)}$
11. acetic acid
12. $HIO_{3(aq)}$

Page F9 : Molecular Substances

1. silicon tetrahydride
2. Br_2
3. arsenic trifluoride
4. $CC\ell_4$
5. H_2S
6. sulfur dioxide
7. I_2
8. nitrogen trichloride
9. N_2O_5
10. ammonia
11. nitrogen
12. $BrC\ell$
13. phosphorus trihydride
14. CS_2
15. SO_3
16. methane
17. N_2O_3
18. tetraphosphorus decoxide
19. $C_{12}H_{22}O_{11}$
20. sulfur hexafluoride

REVIEW OF CHEMISTRY 10

Answer Key

Page F10 : Chemical Nomenclature

1. aluminum hydroxide
2. Na_2SO_4
3. $NaNO_3$
4. aluminum sulfate
5. $CaC\ell_2$
6. ammonium hydroxide
7. H_2O_2
8. dinitrogen monoxide
9. CH_4
10. sulfuric acid
11. phosphoric acid
12. $H_3BO_{3(aq)}$
13. ammonium sulfate
14. tin(II) (stannous) fluoride
15. $H_2CO_{3(aq)}$
16. lead(IV) (plumbic) oxide
17. SiO_2
18. sodium hypochlorite
19. $KMnO_4$
20. potassium nitrate
21. potassium carbonate
22. $HF_{(aq)}$
23. carbon
24. NaOH
25. sodium bisulfate
26. $MgSO_4$
27. calcium hydroxide
28. $Na_2S_2O_3$
29. calcium oxide
30. $CuSO_4$
31. S_8
32. diboron hexahydride
33. potassium iodide
34. P_4
35. sulfur trioxide
36. $NaC\ell O_3$
37. sodium silicate
38. CH_3OH
39. $HC\ell O_{3(aq)}$
40. $PbSO_4$
41. calcium bicarbonate
42. $NC\ell_3$
43. $NaHSO_3$
44. carbon disulfide
45. hydrosulfuric acid
46. SiC
47. $A\ell PO_4$
48. HNO_3
49. silicon carbide
50. dinitrogen tetrahydride

Page F11 : Balancing Equations and Identifying Reaction Type

1. 4,3,2 simple composition
2. 2,1,21 double replacement
3. 1,2,12 hydrocarbon combustion
4. 1,1,1,1 single replacement
5. 1,1,1 composition (or other)
6. 2,2,1 simple decomposition
7. 1,1,1 decomposition (or other)
8. 2,1,1,2 double replacement
9. 1,2,1,2 double replacement
10. 1,3,2,3 double replacement
11. 1,3,2,3,6 other
12. 2,25,16,18 hydrocarbon combustion
13. 2,1,1,2 double replacement
14. 1,1,1 composition (or other)
15. 1,2,1,1 single replacement
16. 3,2,6,1 double replacement
17. 1,1,2,2 other
18. 1,1,2,1 double replacement

TEACHERS' GUIDE

REVIEW OF CHEMISTRY 10

Answer Key

Page F16 : Mole Calculations

1.	$Na_2Cr_2O_7$	262 g/mol	0.500 mol
2.	$Pb(CH_3COO)_2 \cdot 3H_2O$	379 g/mol	79.6 g
3.	SO_2	64.1 g/mol	103 g
4.	potassium carbonate	138.2 g/mol	0.599 mol
5.	$A\ell_2O_3$	102 g/mol	0.250 mol
6.	copper(II) (cupric) chlorate	231 g/mol	578 g

Page F17 : Mole Calculations

1.	$NaC\ell$	58.5 g/mol	14.6 g
2.	potassium hydroxide	56.1 g/mol	0.0822 mol
3.	ammonium sulfate	132.2 g/mol	52.9 g
4.	SiO_2	60.1 g/mol	135 g
5.	calcium nitrate	164.1 g/mol	0.0499 mol

Page F19 : Mole Calculations

1.	calcium oxide	56.1 g/mol	0.001 78 mol
2.	Na_2CO_3	106 g/mol	0.006 67 g
3.	$A\ell_2(SO_4)_3$	342 g/mol	0.000 021 9 mol
4.		12.0 g/mol	0.0150 g
5.	$(NH_4)_2SO_4$	132 g/mol	0.000 022 7 mol
6.	chlorine	71.0 g/mol	0.000 500 g
7.		110 g/mol	0.000 004 55 mol
8.		144 g/mol	0.000 005 56 mol

Pages F22 - F25 : Gravimetric Stoichiometry

1. 1.00 mol $A\ell(OH)_3$
   1.50 mol K_2SO_4
2. 704 g
3. 2.50 mol
4. 10.8 g
5. 0.0400 mol N_2
   0.120 mol $C\ell_2$
6. 506 g $BaCrO_4$
   298 g $KC\ell$
7. a. 15.0 mol
   b. 9.00 mol CO_2
   12.0 mol H_2O
8. 108 g
9. 0.200 mol $CuSO_4$
   0.400 mol Ag
10. 0.250 mol H_2
    0.125 mol O_2
11. 9.22 g
12. 16.5 g

TEACHERS' GUIDE
CHEMICAL BONDING

General Information

1. The concept of chemical bonding is introduced from the premise that bonded species are at a lower energy condition than the unbonded species. It is considered that the energy lowering effects arise from electrostatic interactions. This thread of emphasis, initially made with respect to covalent bonding, is extended to other bond types.

2. Bonding between atoms is extended to include not only covalent and ionic bonding but also network covalent and metallic bonding. The sections on network covalent bonds and metallic bonds is optional.

3. The Chem Study film *Chemical Bonding* may be useful as an introduction to covalent bonding.

4. Covalent bonding is considered to occur between atoms of nonmetals and ionic bonding is considered to occur between ions of metals and nonmetals (or complex anions). No attempt is made to ascertain bond types with reference to percent of ionic character or relative difference between electronegativities of atoms.

5. Differences between ionic and molecular substances may be illustrated by contrasting the melting point, hardness and crystalline structure of substances such as NaCl cubes and roll sulfur.

6. Students should learn to identify covalent bonds as nonpolar covalent or polar covalent.

7. VSEPR (Valence Shell Electron Pair Repulsion) Theory is used for determining molecular shapes. This method is simpler than orbital theory but yet provides a reliable basis for understanding and predicting molecular shapes. A complete description of VSEPR Theory is provided in a book entitled *Molecular Geometry* by R. T. Gillespie. A much more concise description of VSEPR Theory is given in the March, 1973 issue of *Chemistry*.

8. A class demonstration kit consisting of molecular models of methane, ammonia, water, ethene and ethyne would be useful in illustrating the basic molecular shapes described in this unit.

9. The Chem Study film *Shapes and Polarities of Molecules* would be useful in illustrating the properties of polar and nonpolar molecules.

10. A somewhat modified approach to intermolecular bonding is presented. Van der Waals forces are considered to be a composite of three types of intermolecular forces: 1. dipole-dipole forces, 2. dipole-induced dipole forces, and 3. London dispersion forces. Of these three types London dispersion forces are the most significant. The other main type of intermolecular force is considered to be hydrogen bonding. The classification of intermolecular forces described, though differing from that presented in some textbooks, is the more correct.

11. A demonstration of the principle of *like dissolves like* might include the attempted dissolving of:

    a. $I_{2(s)}$ in water
    b. $I_{2(s)}$ in $CC\ell_{4(\ell)}$
    c. benzene$_{(\ell)}$ in water
    d. benzene$_{(\ell)}$ in $CC\ell_{4(\ell)}$
    e. $NaC\ell$ in water
    f. $NaC\ell$ in ethanol
    g. $NaC\ell$ in $CC\ell_{4(\ell)}$ or other organic nonpolar solvent

12. The miscibility of water and alcohol, and the dramatic reduction in volume as they dissolve, is a good demonstration of hydrogen bonding forces.

13. The relative weakness of van der Waal's forces may be demonstrated by the relatively low melting points and by the volatility of bromine, iodine, sulfur, the alkanes and other nonpolar substances.

Shapes of Molecules - Lab G1 (Pages G24 and G25)

1. Students may use ball and spring or ball and stick model kits for this experiment.

2. One molecular model kit should be made available per group of two students.

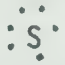
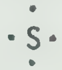
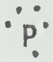
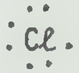
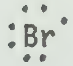
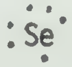
3. The column headed *Representation for Actual Shape* requires the students to draw three dimensional representations for the molecules. The representations are to be done according to the usual convention that a solid line indicates bonds directed in the plane of the paper, a dotted line indicates bonds directed into the plane of the paper and a wedge indicates bonds directed out of the plane of the paper.

Biography of a Chemist

The biography of a chemist as outlined on Page G42 is an optional activity that may be done at any time during the ALCHEM 20 course.

Answer Key

Page G6 : Lewis Diagram for Atoms

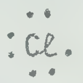
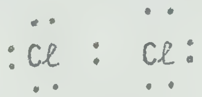
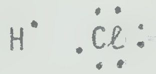
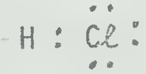
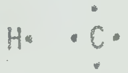
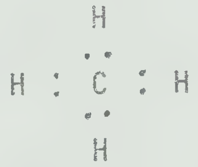
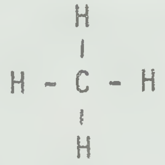
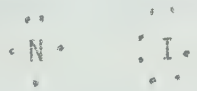
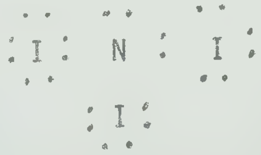
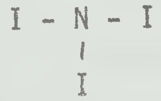
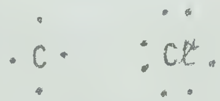
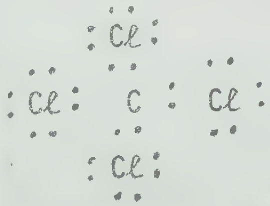
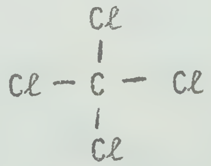
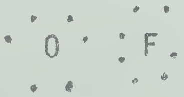
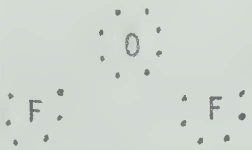
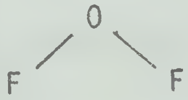
Atom	Group	Number of Valence Electrons	Number of Lone Pairs	Number of Bonding Electrons	Lewis Diagram
S	VIA	6	2	2	
Si	IVA	4	0	4	
P	VA	5	1	3	
Cℓ	VIIA	7	3	1	
Br	VIIA	7	3	1	
Se	VIA	6	2	1	

TEACHERS' GUIDE
CHEMICAL BONDING

Answer Key

Page G8: Lewis Diagrams and Structural Formula:

Note: The underlined are given

	Molecular Substance	Molecular Formula	Lewis Diagram of Atoms	Lewis Diagram of Molecule	Structural Formula
1.	hydrogen	$\underline{H_2}$	H·	H : H	H - H
2.	chlorine	$C\ell_2$			Cℓ - Cℓ
3.	hydrogen chloride	$\underline{HC\ell}$			H - Cℓ
4.	methane	CH_4			
5.	nitrogen triodide	$\underline{NI_3}$			
6.	carbon tetrachloride	$CC\ell_4$			
7.	oxygen difluoride	$\underline{OF_2}$			

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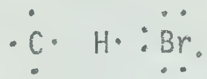
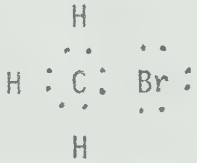
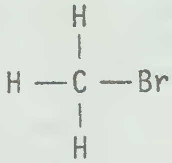
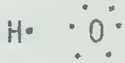
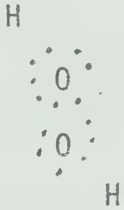
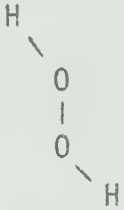
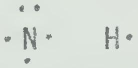
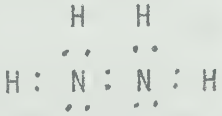
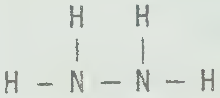
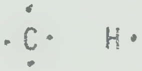
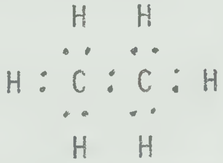
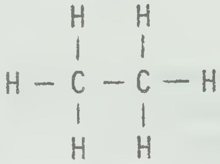
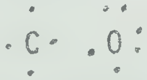
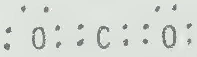
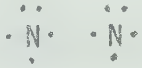
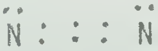
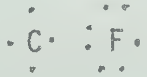
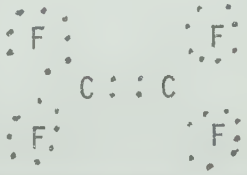
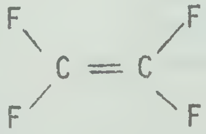
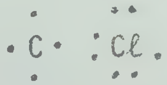
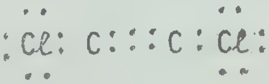
CHEMICAL BONDING

Answer Key

Page G9: Lewis Diagrams and Structural Formulas

	Molecular Substance	Molecular Formula	Lewis Diagram of Atoms	Lewis Diagram of Molecule	Structural Formula
8.	methyl bromide	CH_3Br			
9.	hydron peroxide	H_2O_2			
10.	hydrazine	N_2H_4			
11.	ethane	C_2H_6			
12.	carbon dioxide	CO_2			$O=C=O$
13.	nitrogen	N_2			$N\equiv N$
14.	tetrafluoro-ethene	C_2F_4			
15.	dichloro-ethyne	C_2Cl_2			$Cl-C\equiv C-Cl$

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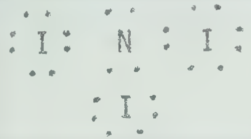
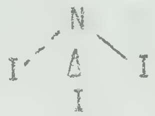
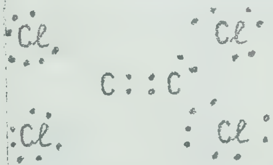
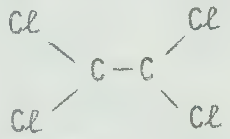
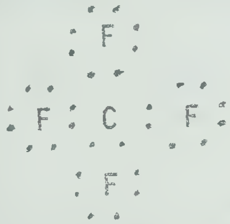
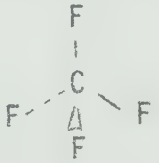
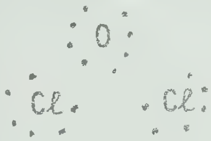
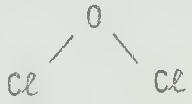
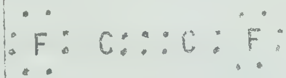
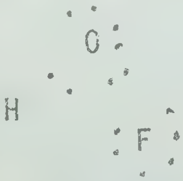
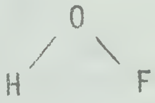
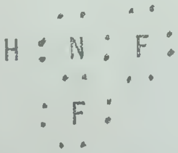
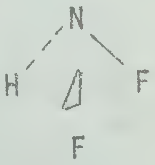
CHEMICAL BONDING

Answer Key

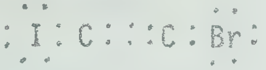
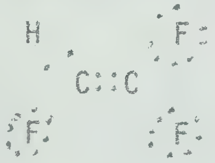
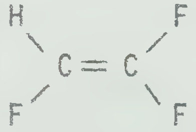
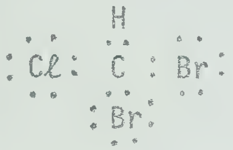
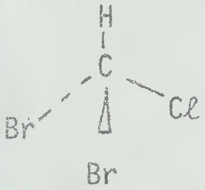
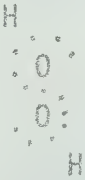
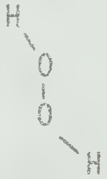
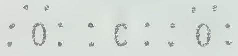
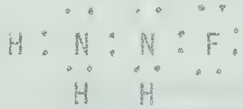
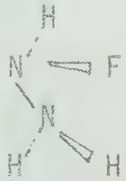
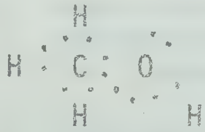
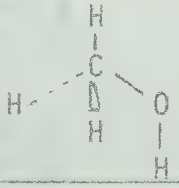
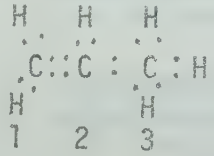
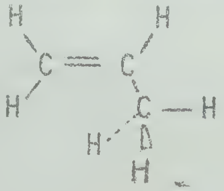
Page G11 : Shapes of Molecules

Molecular Substance	Lewis Diagram	# of Lone Pairs	# of Bonds	Name to Represent Predicted Shape	Representation for Actual Shape	Name to Represent Actual Shape
NI_3		1	3			pyramidal (around N atom)
C_2Cl_4		9	3			trigonal planar(around each C atom
CF_4		0	4			tetrahedral (around C atom)
OCl_2		2	2			V-shaped (around O atom)
C_2F_2		0	2		F — C — C — F	linear (around each C atom)
HOF		2	2			V-shaped (around O atom)
NHF_2		1	3			pyramidal (around N ato actually modified pyramidal

Note: The first column is given.

Answer Key

Page G12 : Shapes of Molecules

Molecular Substance	Lewis Diagram	# of Lone Pairs	# of Bonds	Name to Represent Predicted Shape	Representation for Actual Shape	Name to Represent Actual Sha
C_2IBr		0	2 (around each C atom)		I—C≡C—Br	linear (around ea C atom)
C_2HF_3		0	3			trigonal planar (around ea C atom)
$CHC\ell Br_2$		0	4			tetrahedra (around C atom) -actually modified tetrahedra
H_2O_2		2	2			V-shaped (around each O ator
CO_2		0	2		O = C = O	linear (around C atom)
N_2H_3F		1	3			pyramidal (around e N atom)
CH_3OH		0 around C 2 around O	4 around C 2 around O			tetrahedra (around C) V-shaped (around O)
C_3H_6		0	3 around c's 1&2 4 around C-2			trigonal planar (around c's 1 & 2) tetrahedral (around C-3)

TEACHERS' GUIDE
CHEMICAL BONDING

Answer Key

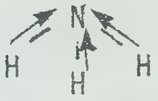
Page G13 : Comparing Electronegativities of Atoms

a. N   b. H   c. I
d. Cℓ   e. Br   f. Cℓ   g. Cℓ

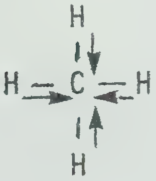
Page G15 and G16 : Polarity of Bonds

1. a. $\overline{H} - F$

b.



c.



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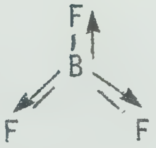
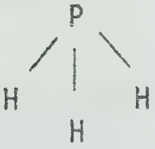
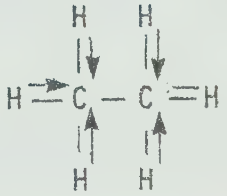


e. $N \equiv N$

f.



g.



2. a. electronegativity difference between H and O = 1.4
electronegativity difference between S and O = 1.0
H - O bond is more polar

b. electronegativity difference between H and O = 1.4
electronegativity difference between H and S = 0.4
H - O bond is more polar

c. electronegativity difference between B and O = 1.5
electronegativity difference between C and O = 1.0
B - O bond is more polar

d. electronegativity difference between H and Cℓ= 0.9
electronegativity difference between N and F = 1.0
N - F bond is more polar

e. electronegativity difference between N and Cℓ= 0
electronegativity difference between P and Cℓ= 0.9
P - Cℓ bond is more polar

f. electronegativity difference between Si and Br = 1.0
electronegativity difference between C and Br = 0.3
Si - Br bond is more polar

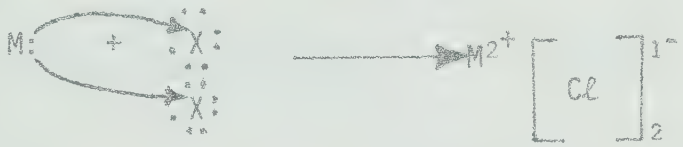
TEACHERS' GUIDE
CHEMICAL BONDING

Answer Key

3. The pair of shared electrons in $C\ell F$ is closer to the more electronegative F atom than to the chlorine atom giving the chlorine a partial positive charge.

Page G19 and G20 : Ionic Bonds

1. a. ionic
   b. crystal
   c.



2. In polar covalent bonds there is charge separation because of the difference between the electronegativities of the atoms bonded. If electronegativities of bonded atoms become sufficiently great, charged separation can reach a condition at which the shared electron becomes the property of the more electronegative atom. This leads to electrons transfer and results in ionic bonding.

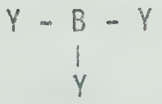
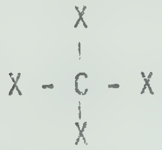
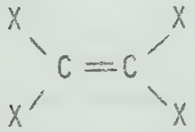
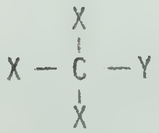
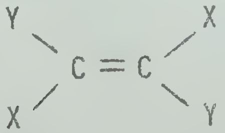
3. Ions, the structural units of ionic compounds, are formed by transfer of one or more electrons from one atom to another. The force of attraction between charged ions is called an ionic bond.

4. a. $KC\ell$ ionic
   b. HI covalent
   c. LiBr ionic
   d. CH_4 covalent
   e. CaS ionic
   f. H_2S covalent

5. a. polar covalent
   b. polar covalent
   c. nonpolar covalent
   d. ionic
   e. ionic
   f. ionic
   g. polar covalent
   h. polar covalent

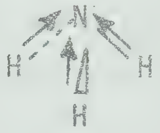
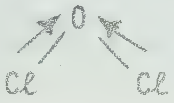
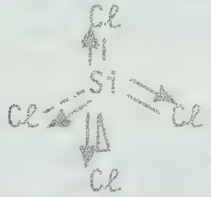
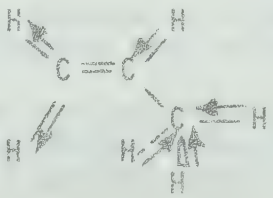
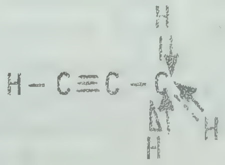
Answer Key

G27 : Polarity of Molecules

Structural Formula	Name to Represent Actual Shape	Polarity of Bond(s)	Polarity of Molecule
e.g. $A = A$	linear	nonpolar	nonpolar
1. $X - A - X$	linear or v-shaped	polar	nonpolar if linear polar if v-shaped
2. $X - A - Y$	linear or v-shaped	polar	polar (regardless if linear or v-shaped)
3.  $Y - \underset{\underset{Y}{\mid}}{B} - Y$	pyramidal	polar	polar
4.  $X - \overset{\overset{X}{\mid}}{\underset{\underset{X}{\mid}}{C}} - X$	tetrahedral	polar	nonpolar
5. 	trigonal planar (around each C)	polar	nonpolar
6. $X - C \equiv C - X$	linear	polar	nonpolar
7.  $X - \overset{\overset{X}{\mid}}{\underset{\underset{X}{\mid}}{C}} - Y$	tetrahedral (modified)	polar	polar
8. 	trigonal planar (modified)	polar	nonpolar

Answer Key

Page G28 : Polarity of Molecules

Molecular Formula	Molecular Shape and Bond Dipoles	Name of Molecular Shape	Polarity of Molecule
NH_3		pyramidal	polar
1. N_2	$N \equiv N$	linear	nonpolar
2. HBr	$\overrightarrow{H - Br}$	linear	polar
3. $OC\ell_2$		v-shaped	polar
4. $SiC\ell_4$		tetrahedral	nonpolar
5. C_3H_6		trigonal planar 2 carbons and tetrahedral around one	nonpolar
6. C_3H_4		linear around 2 carbons and tetrahedral around one	nonpolar

TEACHERS' GUIDE
CHEMICAL BONDING

Answer Key

Page G32 : Table

Element	Number of Electrons	Boiling Point (°C)
F_2	18	-188
$C\ell_2$	34	-35
Br_2	70	59
I_2	106	184

Above information can be obtained from the table on page G39

Page G36 : Intermolecular Forces

2. London dispersion forces increase with an increase in molecular size, i.e., increase with an increase in the number of electrons in atoms or molecules. Ar and F_2 are isolectronic, therefore their boiling points are approximately the same.

3. Both Kr and HBr are isolectronic but HBr has a significantly higher boiling point than Kr because each feels the effect of London dispersion forces, but HBr, being polar, feels the added effect of dipole-dipole forces and dipole-induced dipole forces.

4. The explanation proposed in question 3 applies here because $C\ell_2$ is nonpolar and $C_2H_5C\ell$ is polar and experiences the added effect of dipole-dipole forces and dipole-induced dipole forces.

5. The first hydrogen compounds of Groups VA, VIA and VIIA elements display a reversal in trend because each of these compounds involve hydrogen bonding.

6. The first member of the Group IVA hydrogen compounds does not show the reversal in trend displayed by the first hydrogen compound of the other elements because it does not involve hydrogen bonding.

7. The boiling points of the Group IVA hydrogen compounds exhibits consistently lower boiling points than the other hydrogen compounds because Group IVA elements experience van der Waals due only to London dispersion forces. The other hydrogen compounds experience van der Waals forces due not only to London dispersion forces but also due to dipole-dipole forces and dipole-induced dipole forces.

Answer Key

Page G39 : Table G9

Substance	Number of Electrons	Boiling Point (°C)	Types of Intermolecular Forces: van der Waals: dipole-dipole	van der Waals: dipole-induced dipole	London dispersion	Hydrogen Bonding
e.g. F_2	18	-188			✓	
1. $C\ell_2$	34	-35			✓	
2. Br_2	70	59			✓	
3. I_2	106	184			✓	
4. $C\ell F$	26	-101	✓	✓	✓	
5. BrF	44	-20	✓	✓	✓	
6. $BrC\ell$	52	5	✓	✓	✓	
7. $IC\ell$	70	97	✓	✓	✓	
8. IBr	88	116	✓	✓	✓	
9. CH_4	16	-162			✓	
0. C_2H_6	18	-87			✓	
1. $n\text{-}C_3H_8$	26	-45			✓	
2. $n\text{-}C_4H_{10}$	34	-0.50			✓	
3. $n\text{-}C_5H_{12}$	72	36			✓	
4. CF_4	42	-129			✓	
5. $CC\ell_4$	74	77			✓	
6. CBr_4	146	189			✓	
7. CH_3F	18	-78	✓	✓	✓	
8. $CH_3C\ell$	26	-24	✓	✓	✓	
9. CH_3Br	44	3.6	✓	✓	✓	
20. CH_3I	62	43	✓	✓	✓	
21. CH_3OH	18	65	✓	✓	✓	✓
22. C_2H_5F	26	-38	✓	✓	✓	
23. $C_2H_5C\ell$	34	13	✓	✓	✓	
24. C_2H_5Br	52	38	✓	✓	✓	
25. C_2H_5I	70	72	✓	✓	✓	
26. C_2H_5OH	26	78	✓	✓	✓	✓

TEACHERS' GUIDE
CHEMICAL BONDING

Answer Key

Page G4 : Intermolecular Bonding

7. The boiling point of ICℓ is higher than that of Br_2 in spite of their being isoelectronic because in nonpolar Br_2 van der Waals forces are only due to London dispersion forces. In polar ICℓ van der Waals forces have the added effect of dipole-dipole forces and dipole-induced dipole forces.

8. The explanation in number 7 also applies to BrF and n-C_3H_8 since BrF is polar and n-C_3H_8 is nonpolar.

9. Van der Waals forces, due to London dispersion forces, increase with an increase in the number of electrons in an atom or molecule. (It is also likely that dipole-induced dipole forces increase with an increase in the number of electrons in an atom or molecule.)

10. Both CH_3OH and C_2H_5OH exhibit hydrogen bonding which is the strongest of intermolecular forces.

TEACHERS' GUIDE
ORGANIC CHEMISTRY

General Information

1. Students are expected to learn the IUPAC (International Union of Pure and Applied Chemistry) names and the molecular and structural formulas for:
    - a. the first ten members of the alkane series, their cyclic counterparts and some simple isomers
    - b. the first ten members of the alkene series, their cyclic counterparts and some simple isomers
    - c. the first ten members of the alkyne series, their cyclic counterparts and some simple isomers
    - d. benzene and some benzene substituted compounds (aromatics)
    - e. some simple organic halides
    - f. alcohols and some simple isomers and two polyhydroxy alcohols—1, 2-ethanediol and 1, 2, 3- propanetriol
    - g. carboxylic acids (first ten straight chain)
    - h. some simple esters.

2. An available reference for IUPAC nomenclature is the CRC (*Chemical Rubber Company*) *Handbook of Chemistry and Physics*.

3. Some of the more important concepts that students should learn about properties of organic compounds relates to such things as:
    - a. the nature and relative magnitude of intermolecular forces and their effect upon boiling point and solubility in water
    - b. the relative chemical reactivity and tendency to undergo such reactions as substitution and addition
    - c. those properties that pertain to the important applications of some organic compounds.

4. Molecular models are useful in describing the shape and polar nature of any organic compound. It is suggested that a demo kit of the following molecular models be preconstructed for use in this unit:
    - a. methane
    - b. propane and/or butane
    - c. a cycloalkane (cyclohexane)
    - d. ethene and/or propene
    - e. a cycloalkene (cyclohexene)
    - f. ethyne and/or propyne
    - g. a cycloalkyne (cyclohexyne)
    - h. benzene and some substituted benzene compounds
    - i. 1,1,2,2-tetrachloroethene
    - j. methanol and ethanol
    - k. 1,2-ethanediol and 1,2,3-propanetriol
    - l. methanoic and ethanoic acids
    - m. some simple esters

5. A demo kit consisting of samples of the following organic compounds in vials would be useful in this unit.

   a. hexane and cyclohexane

   b. benzene and some of its derivatives, e.g., phenol, 1,4-dichlorobenzene and toluene

   c. 1,1,2,2-tetrachloroethene

   d. methanol, ethanol and 2-propanol

   e. 1,2-ethanediol and 1,2,3-propanetriol

   f. methanoic and ethanoic acids

   g. an ester

6. The follow-up to the organic chemistry in this unit is the elective unit in Chemistry 30 entitled Foods and Their Analogs. The major topics included in the Foods and Their Analogs unit are:

   a. lipids (esterification, lipid formation, fats vs. oils, hydrogenation, catalysis, hydrolysis and soaps and detergents).

   b. proteins (amines, amides, amino acids, polymerization (in regard to polyamides and proteins) and pH dependence upon function of protein molecules).

   c. Carbohydrates (aldehydes, ketones, aldoses and ketoses, monosaccharides, disaccharides and polysaccharides).

Fractional Distillation - Demo H1 (Pages H12 and H13)

1. The fractional distillation of hydrocarbons (hexane and 1-hexanol) is suggested as a demonstration rather than a student lab because of
   a. the unavailability of class sets of heating mantles
   b. the unavailability of class sets of condensers
   c. the fire hazard if a bunsen burner is used
   d. the general undesirability of exposure to increased concentrations of vapors when a large number of people are simultaneously heating organic compounds, and
   e. the difficulty in maintaining a high enough temperature for distillation using tap water.

2. An alternate demonstration and/or lab that works well is the fractional distillation of a two component mixture using a combination of methanol and water.

3. Distillation mixtures in any reasonable proportions may be made up. For experimental significance and practicability, it may be advisable to avoid 50% two component mixtures, or mixtures where the amount of any component is too low.

4. The boiling point at standard pressure of the components in the mixture(s) suggested are:

hexane - 68°C
methanol - 65°C
1-hexanol - 158°C

No. Req'd	Item	Joint Size	Price Per Item
2	Condenser (ground glass joints)	24/29	9.02
2	Boiling Flasks	24/29	4.07
	Stainless Steel Wool		Not Listed in Canlab
1	Connecting Tube with thermometer opening	24/40 & 10/30	7.71
1	Connecting Tube with suction arm	24/40	7.56
1	Mantle with Aℓ housing	-	25.32
1	Thermometer (-10 to 250°C and ground joint	10/30	12.16

(The above information is from the 1975 Canlab catalogue)

TEACHERS' GUIDE
ORGANIC CHEMISTRY

Molecular Models of Alkanes and Alkenes - Lab H1 (Page H24)

1. If molecular model kits are not available, styrofoam balls of two different sizes, the larger for carbons and the smaller for hydrogen, may be used. If styrofoam balls are used, some preliminary instruction regarding the relative positioning of the bonds would be required.

2. Part 1 requires the students to construct two isomeric forms for the fourth member, and three isomeric forms for the fifth member of the alkane series.

3. Part 2 requires the students to recognize two isomeric forms of butene as determined by the location of the double bond. A third isomeric form with a methyl branch is possible. Teachers may wish to extend isomeric forms of butene to include their cis-and trans-isomeric forms.

Reactions of Cyclohexane, Cyclohexene and Benzene - Lab H2 (Page H34)

1. It is suggested that reagents for this lab be provided in dropper bottles.

2. The reaction solutions for this lab can be made up as follows:

   a. solution of Br_2 in CCl_4

      Use 3 mℓ of Br_2 per 100 mℓ of CCl_4

   b. $KMnO_4$ solution

      Use 0.20 g $KMnO_4$, and add water to make up 100 mℓ of solution.

      (100 mℓ of this solution per class should be more than adequate)

3. Use reagent grade cyclohexane, cyclohexene and benzene as impurities will affect the reactions.

4. U.V. lamp(s), if available, might be set up for use in the reactions involving hydrocarbons and Br_2. U.V. light is required for the reactions of Br_2 with hexane. However, allowing the reaction mixture of hexane and Br_2 to stand in the lab for about ten minutes should give adequate results.

5. Cyclohexene reacts almost instantaneously with both Br_2 and $KMnO_4$. Cyclohexane, after exposure to U.V. will undergo a substitution reaction with Br_2. The litmus test should indicate evolution of HBr and therefore a substitution reaction of Br_2 with cyclohexane. Neither cyclohexane nor benzene will react with $KMnO_4$ under the conditions given for this lab. Some discoloration may occur due to the impurities in the reagents.

6. Some impurities can be removed from cyclohexane by adding H_2SO_4, shaking, then separating using a separatory funnel.

7. Caution students not to tightly stopper the test tubes containing the hydrocarbons. The high volatility of the hydrocarbons may cause sufficient pressure build-up to burst tightly stoppered test tubes.

8. The students will find this lab less confusing if part A is done one day and part B is done on a second day.

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ORGANIC CHEMISTRY

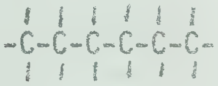
Esterification - Lab H3 (Page H51)

1. Students should be reminded of the potential hazard involved when working with concentrated acids such as sulfuric acid. A bottle of 1 M $NaHCO_3$ should be readily available in case of accident.
2. The correct technique for testing the odor of substances by wafting with the hand should be demonstrated to the students.
3. Although results using some of the vile smelling chemicals (e.g., butanoic acid and octanol) may be more successful, these were intentionally avoided because of the obvious undesirability of working with them.
4. Salicylic acid is a solid at room temperature. The addition of methanol will dissolve the salicylic acid and sufficient reaction should occur at the temperature of the water bath to give the distinct odor of the ester.
5. The particular odor of the ester that should result is given in the lab procedure.

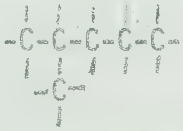
Answer Key

Pages H5 and H6 : Nomenclature of Alkanes

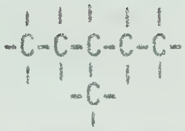
1.



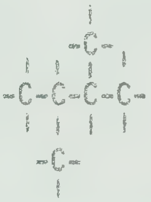
hexane



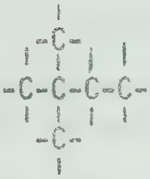
2-methylpentane



3-methylpentane



2,3-dimethylbutane



2,2-dimethylbutane

2. The name is unsuitable because the ethyl group designated as a branch is part of the longest chain. This compound should be named 3,3,5-trimethylheptane.

3. a. 3-ethylpentane

   b. 2,3-dimethylbutane

   c. 2-methyl-3-ethylpentane

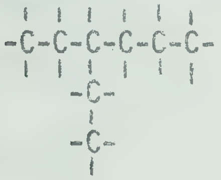
   d. 3-methyl-4-ethylhexane

   e. 4-methyl-8-propylundecane (This one was an oversight since students at this level are not responsible for naming hydrocarbon chains in excess of 10 carbons)

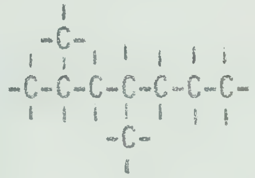
   f. 3-ethyl-5-propyloctane

Answer Key

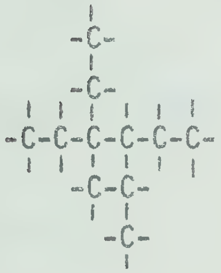
4. a. impossible; substitute with 3-ethylhexane



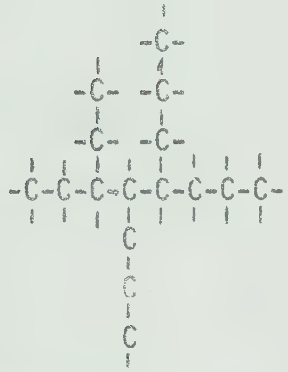
b.



c.



d.



Page H13 : Fractional Distillation - Demo H1

1. Plateaus on the graph of temperature versus time appear during phase changes when average kinetic energy and hence temperature remain constant.
2. There is a relatively rapid rise in temperature between plateaus on the graph of temperature versus time because between phase changes comparatively small quantities of heat produce relatively rapid changes in the average kinetic energy and correspondingly relatively rapid changes in temperature.
3. Hexane involves relatively weak van der Waals intermolecular forces whereas hexanol involves much stronger hydrogen bonding intermolecular forces.

Page H15 : Names and Structural Formulas of Alkenes

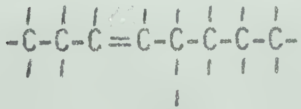
1. a. 2-hexene

b. 2-methyl - 2-butane

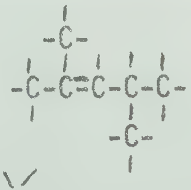
c. 3,3-dimethyl-1-pentene

d. 2-methyl-4-ethyl-2-hexene

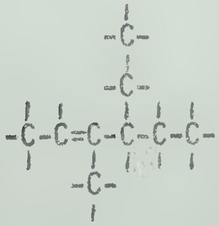
2. a.



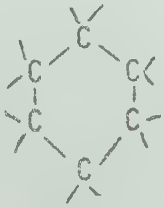
b.



c.



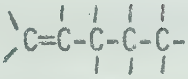
d.



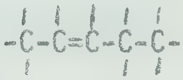
TEACHERS' GUIDE
ORGANIC CHEMISTRY

Answer Key

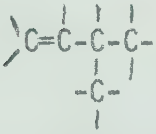
3.



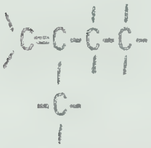
1-pentene



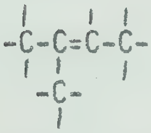
2 pentene



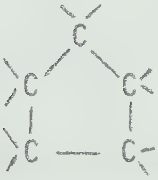
3-methyl-1-butene



2-methyl-1-butene



2-methyl-2-butene



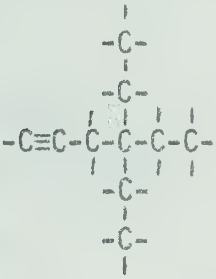
cyclopentane

Answer Key

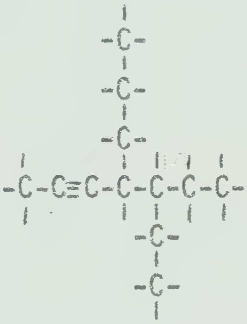
Page H19 : Names and Structural Formulas of Alkynes

1. a. 3-methyl-1-butyne b. 4-methyl-2-hexyne

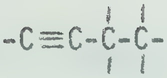
2. a.



b.

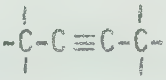


3.



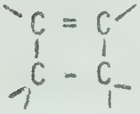
$-C\equiv C-C-C-$

1-butyne



$-C-C\equiv C-C-$

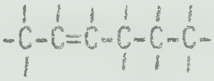
2-butyne



cyclobutene

Page H22 : Alkanes, Alkenes, Alkynes

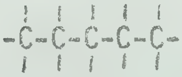
1. C_6H_{12}



$-C-C=C-C-C-C-$

2. 1-butene C_4H_6

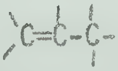
3. pentane



$-C-C-C-C-C-$ (isomers possible)

4. 3-heptene C_7H_{14}

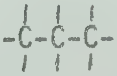
5. propene



$C=C-C-$

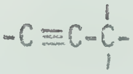
6. C_2H_2 $-C\equiv C-$

7. C_3H_8

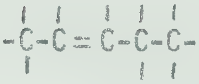


$-C-C-C-$

Answer Key

8. propyne  $-C\equiv C-C-$

9. 2-butyne C_4H_6

0. C_5H_{10}  $-C-C=C-C-C-$

1. tetrahedral

2. trigonal planar

3. linear

4. four electrons

age H26 : Molecular Models of Alkanes and Alkenes - Questions

art A

1. 2, CH_2

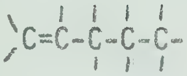
2. isomers

3. saturated

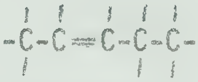
art B

1. CH_2

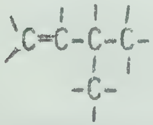
2.

 $C=C-C-C-C-$

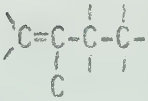
1 pentene

 $-C-C=C-C-C-$

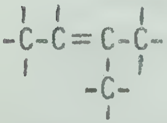
2-pentene

 $C=C-C-C-$

3-methyl-1-butene

 $C=C-C-C-$

2-methyl-1-butene

 $-C-C=C-C-$

2-methyl-2-butene

Answer Key

Pages H29 and H30 : Nomenclature of Aromatic Hydrocarbons

1. a. 2-phenylbutane

b. 1,2-dimethylbenzene,
O-dimethylbenzene, or
O-methyltoluene

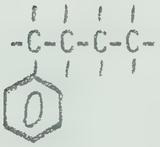
c. 4-methylpropylbenzene,
p-methylpropylbenzene, or
p-propyltoluene

d. 1-methyl-2-phenylbutane

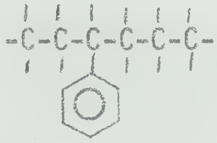
e. 3-ethyl-3-phenylpentane

f. 1-propyl-3,5-dimethylbenzene,
3,5-dimethylpropylbenzene, or
3-propyl-5 methyltoluene

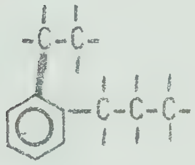
2. a.



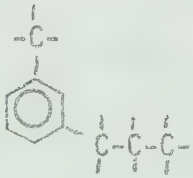
b.



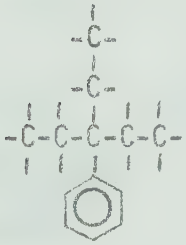
c.



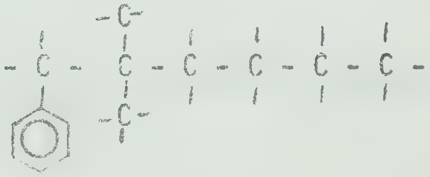
d.



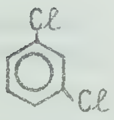
e.



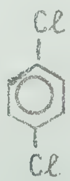
f.



g.



1,3-dichlorobenzene or
m-dichlorobenzene



1,4-dichlorobenzene
p-dichlorobenzene

Answer Key

Page H35 : Reactions of Cyclohexane, Cyclohexene and Benzene

Hydrocarbon	Color change Immediately after adding Br_2	Effect Upon Litmus Paper Initially	Color Change After Ten Minutes	Effect Upon Litmus Paper After Ten Minutes
Cyclohexane	none	none	Ideally some fading	blue litmus slightly rendered pink
Cyclohexene	solution rendered colorless	none	none	none
Benzene	none	none	none	none

Hydrocarbon	Color Change After One Minute	Color Change After Five Minutes
Cyclohexane	none	none
Cyclohexene	violet $KMuO_4$ solution rendered brownish	brownish solid residue formed
Benzene	none	none

Pages H36 and H37 : Questions (Reactions of Cyclohexane, Cyclohexene and Benzene)

1. a. cyclohexene
   b. cyclohexane
   c. benzene

2. a. cyclohexane
   b. cyclohexene

3. a. Unsaturated aliphatics are much more reactive.
   b. Unsaturated undergo addition reaction and saturated undergo substitution reaction.

4. a. In terms of chemical reactivity it can be concluded that cyclohexene is highly reactive, cyclohexane is moderately reactive and benzene is least reactive. (In reality cyclohexane and benzene are about equally reactive.)
   b. The results indicate that cyclohexene is highly reactive and that cyclohexane and benzene are moderately to nonreactive.
   c. The hydrocarbons that did not react may react under different experimental conditions.

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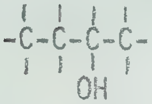
Answer Key

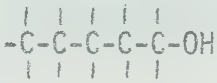
Pages H43 and H44 : Nomenclature of Alcohols

1. a. 1-butanol
   b. 2-methyl-2-butanol
   c. 4-ethyl-2-hexanol
   d. 3,3-dimethyl-1-pentanol

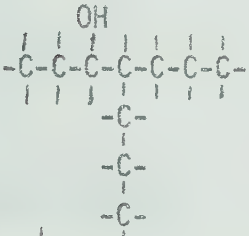
2. a.



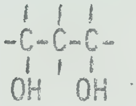
b.



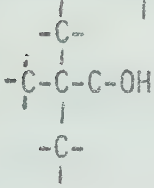
c.



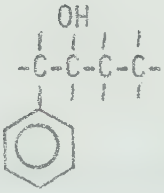
d.



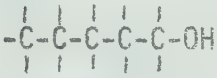
e.



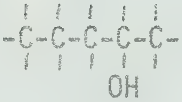
f.



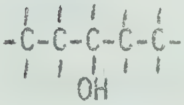
3. Any six of the following:



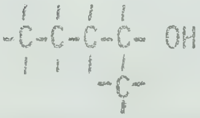
1-pentanol



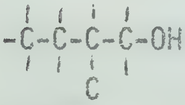
2-pentanol



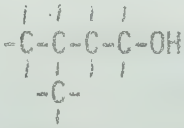
3 pentanol



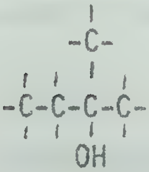
1-methyl-1-butanol



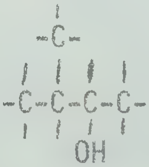
2-methyl-1-butanol



3-methyl-1-butanol

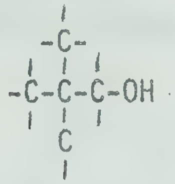


2-methyl-2-butanol



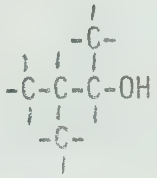
3-methyl-2-butanol

Answer Key



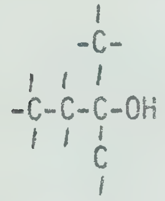
$$\begin{array}{ccc} & | & \\ & -C- & \\ | & | & | \\ -C- & C & -C-OH \\ | & | & | \\ & C & \\ & | & \end{array}$$

2,2-dimethyl-1-propanol
(2,2-dimethylpropanol)



$$\begin{array}{ccc} & | & \\ & -C- & \\ | & | & | \\ -C- & C & -C-OH \\ | & | & | \\ & -C- & \\ & | & \end{array}$$

1,2-dimethyl-1-propanol
(1,2-dimethylpropanol)



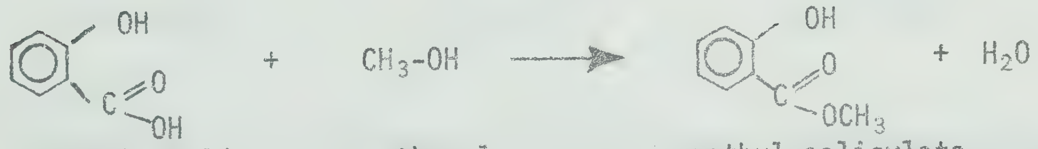
$$\begin{array}{ccc} & & | \\ & & -C- \\ | & | & | \\ -C- & C & -C-OH \\ | & | & | \\ & & C \\ & & | \end{array}$$

1,1-dimethyl-1-propanol
(1,1-dimethylpropanol)

Page H52 - Esterification Lab - Questions

1. The formation of a distinct odor indicates that a chemical reaction has occurred.

2.



salicylic acid + methanol → methyl salicylate + H_2O

CH_3COOH + C_2H_5OH → $CH_3COOC_2H_5$ + H_2O

ethanoic acid, ethanol, ethyl ethanoate

CH_3COOH + C_4H_9OH → $CH_3COOC_4H_9$ + H_2O

ethanoic acid, 1-butanol, butyl ethanoate

CH_3COOH + $C_5H_{11}OH$ → $CH_3COOC_5H_{11}$ + H_2O

ethanoic acid, 1-pentanol, pentyl ethanoate

C_4H_9COOH + $C_5H_{11}OH$ → $C_4H_9COOC_5H_{11}$ + H_2O

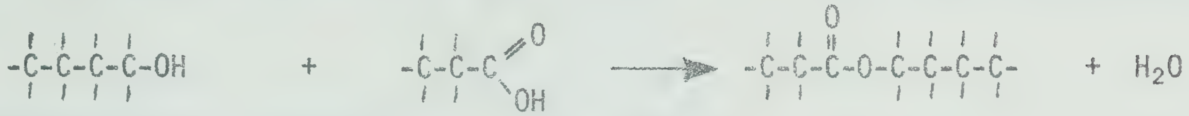
pentanoic acid, 1-pentanol, pentyl pentanoate

TEACHERS' GUIDE
ORGANIC CHEMISTRY

Answer Key

Page H55 : Esters and Esterification

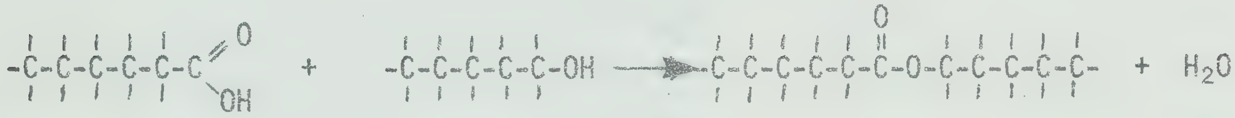
a.



$$\text{-C-C-C-C-OH} + \text{-C-C-}\overset{O}{C}\text{-OH} \longrightarrow \text{-C-C-}\overset{O}{\overset{\|}{C}}\text{-O-C-C-C-C-} + H_2O$$

1-butanol propanoic acid butyl propanoate

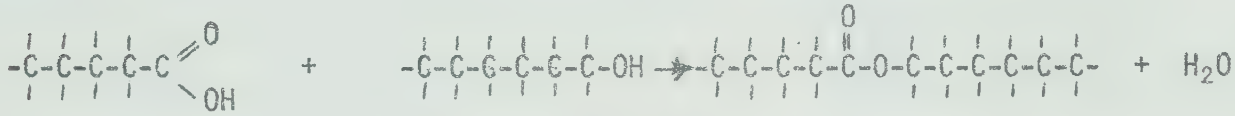
b.



$$\text{-C-C-C-C-C-}\overset{O}{C}\text{-OH} + \text{-C-C-C-C-C-OH} \longrightarrow \text{C-C-C-C-C-}\overset{O}{\overset{\|}{C}}\text{-O-C-C-C-C-C-} + H_2O$$

hexanoic acid 1-pentanol pentyl hexanoate

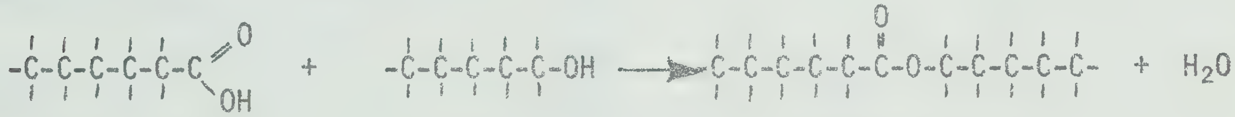
c.



$$\text{-C-C-C-C-}\overset{O}{C}\text{-OH} + \text{-C-C-C-C-C-C-OH} \longrightarrow \text{-C-C-C-C-}\overset{O}{\overset{\|}{C}}\text{-O-C-C-C-C-C-C-} + H_2O$$

pentanoic acid hexanol hexyl pentanoate

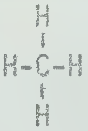
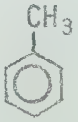
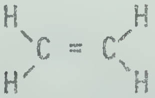
d.



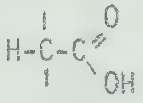
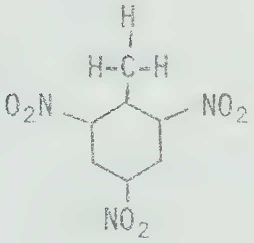
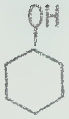
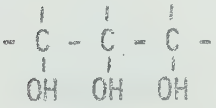
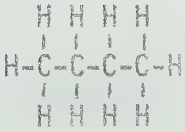
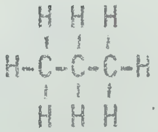
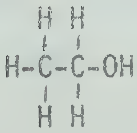
$$\text{-C-C-C-C-C-}\overset{O}{C}\text{-OH} + \text{-C-C-C-C-C-OH} \longrightarrow \text{C-C-C-C-C-}\overset{O}{\overset{\|}{C}}\text{-O-C-C-C-C-C-} + H_2O$$

hexanoic acid pentanol pentyl hexanoate

Pages H57 and H58 : Organic Nomenclature and Uses of Some Organic Compounds

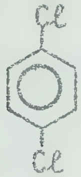
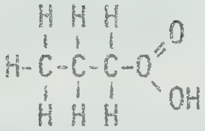
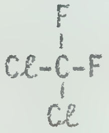
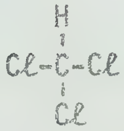
1.	methane	CH_4		
2.	methanol	CH_3OH		gas line and windshield washer antifreeze; solvent for varnishes and shellacs; denaturant for ethanol
3.		$C_6H_5CH_3$		
4.	ethene			manufacture of plastics and synthetic fibres, DDT, synthetic detergents, ethylene glycol, ethylene chloride, tetraethyl lead, paints and drugs

Answer Key

5.		CH_3COOH		ingredient in vinegar, used as a solvent and in photograph
6.	trinitrotoluene	$C_7H_5(NO_2)_3$		
7.	ethyne		$H-C\equiv C-H$	commercial synthesis of fibres (Orlon, Acrilan, Dynel), ethanoic acid, ethanol and othe alcohols, benzene and syntheti rubber; oxy-acetylene welding
8.	1,2-ethanediol (ethylene glycol)	$C_2H_4(OH)_2$		radiator antifreeze
9.	phenol			
10.	1,2,3-propanetriol (glycerin)		 $-\overset{\mid}{\underset{OH}{C}}-\overset{\mid}{\underset{OH}{C}}-\overset{\mid}{\underset{OH}{C}}-$	cosmetics, pharmaceuticals; inks; candy; raw material for some explosives
11.	butane	C_4H_{10}	 $H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$	
12.		C_3H_8	 $H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H$	gaseous fuel
13.	propene	C_3H_6		polymers (polypropene)
14.		C_2H_5OH	 $H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH$	alcoholic beverages, in pharmaceutical industry as solvent and medicinal ingredien in industry as solvent and antifreeze

TEACHERS' GUIDE
ORGANIC CHEMISTRY

Answer Key

15.		$C_6H_5C\ell$		moth repellant
16.	2-propanol	$CH_3CHOHCH_3$		rubbing alcohol; solvent
17.		C_3H_7COOH	 $\begin{array}{c} H\ \ H\ \ H \\ H-C-C-C-O\overset{O}{\diagup}\ \diagdown OH \\ H\ \ H\ \ H \end{array}$	odor-causing agent in rancid butter; flavoring agent
18.	propanoic acid	C_2H_5COOH		salts used as mold inhibitor in baking industry; used as an emulsifier
19.	dichlorodifluoromethane (freon)		 $\begin{array}{c} F \\ \vert \\ C\ell-C-F \\ \vert \\ C\ell \end{array}$	refrigerant; propellant for nonfood aerosol products
20.	trichloromethane (chloroform)		 $\begin{array}{c} H \\ \vert \\ C\ell-C-C\ell \\ \vert \\ C\ell \end{array}$	good solvent; general anaesthetic; sedative; antiseptic

Pages H60 and H61 : Review of Organic Chemistry

1. hydrocarbon
   organic halide (alkyl halide)
   alcohol (alkanol)
   carboxylic acid
   ester

2. a. hydroxyl, carbonyl, ester, benzene, alkyl
   b. chloro, hydroxyl, alkyl
   c. benzene, alkenyl
   d. benzene, ether, carbonyl, aldehyde, carboxylic, hydroxyl, alkyl
   e. chloro, benzene, alkyl
   f. hydroxyl, carbonyl, carboxyl, alkyl
   g. chloro, hydroxyl, alkyl
   h. carbonyl, ester, alkyl

Answer Key

3. ethane - involves van der Waals intermolecular attractions due to only London dispersion forces

   monochloroethane - involves van der Waals intermolecular attractions due to London dispersion forces, dipole-dipole forces and dipole-induced dipole forces; also has more electrons thus London dispersion forces stronger.

   ethanol - involves hydrogen bonding (one hydrogen bond per molecule)

   propanoic acid - involves hydrogen bonding (two hydrogen bonds per molecule)

Chemical Equilibrium Supplement

Since solubility presents the first convenient opportunity for discussing equilibrium, a more detailed analysis of the equilibrium state at this point is appropriate.

The main characteristics to be emphasized are that the equilibrium state:

1. requires a closed system; i.e., a system which does not lose or gain matter.
2. is a dynamic state where two or more opposing processes are taking place at the same time and at the same rate so that no change is apparent.

An analysis of an experiment (below) and the CHEM Study film entitled *Equilibrium* should help students understand the equilibrium state.

$I_{2(s)} - I_{2(aq)}$ Systems

Suppose solid iodine is dissolved in an alcohol-water mixture and the addition of solid iodine is continued until excess, undissolved solute is present. At this point the solution is saturated. It can be verified that the quantity of undissolved iodine remains unchanged by successive filtrations, mass determinations and redissolutions. Since the volume of alcohol-water remains constant, this is a closed system. At saturation no apparent changes are occurring. The color intensity, the volume of solution and quantity of dissolved and undissolved $I_{2(s)}$ all remain constant. However, at the molecular level, processes are continuing. Molecules are leaving the surface of the undissolved iodine and are tending to increase the concentration of iodine in solution. At the same time, dissolved iodine molecules are striking and precipitating upon the undissolved iodine tending to decrease the concentration of iodine molecules in solution. Even though some molecules are dissolving and others are precipitating, no net change is apparent because the two processes are taking place at the same time and at the same rate. In other words, the $I_{2(s)} - I_{2(aq)}$ system is at a state of equilibrium in which

rate of dissolving = rate of precipitation (or crystallization), and

$I_{2(s)} \rightleftharpoons I_{2(aq)}$. (The double arrows indicating a state of equilibrium.)

The dynamic nature of the $I_{2(s)} - I_{2(aq)}$ equilibrium can be confirmed through experiments involving radioactive iodine isotopes. Suppose a saturated solution of iodine is prepared then filtered to remove all excess undissolved iodine. Then a predetermined mass of radioactive $I_{2(s)}$ is added to the saturated solution. Subsequent filtration and testing will indicate two things.

1. The mass of undissolved iodine has remained unchanged.
2. Some radioactive iodine has gone into solution.

Both observations confirm that although the quantity of dissolved and undissolved iodine has remained constant, some dissolving and consequently some precipitation must have occurred.

In general, the $I_{2(s)} - I_{2(aq)}$ system at equilibrium illustrates the typical characteristics of any system at equilibrium, namely,

1. the apparent constancy in regard to quantities of reactants and products at equilibrium, and
2. the dynamic nature in regard to two or more processes taking place at the same time and at the same rate.

TEACHERS' GUIDE

SOLUTIONS

General Information

1. The second part of Unit F, Review of Chemistry 10, should be done preliminary to starting this unit.

2. For the problems on Pages I27-I29, complete dissociation is assumed.

3. The solubility table given on Page I31 will also be on the ALCHEM periodic table.

Preparation of a Solution - Demo I1 (Page I3)

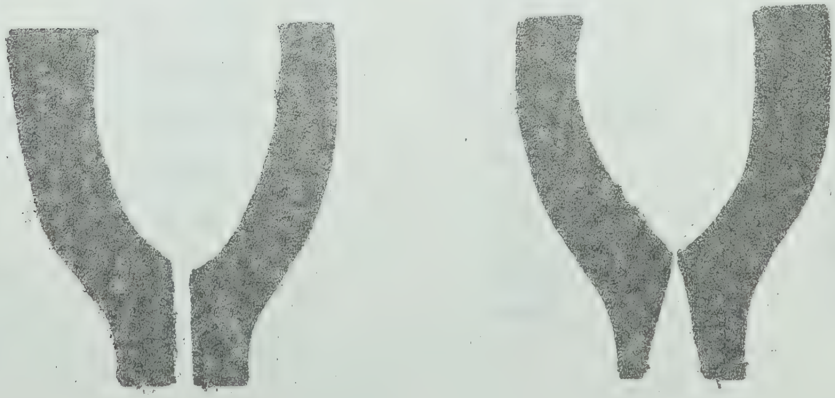
Emphasize to the students that this demo illustrates the correct technique for making solutions of known concentration. Students will follow this technique in Lab I1.

Pipetting Technique - Demo I2 (Page I18)

This demo should be done preliminary to and in conjunction with Lab I1.

Preparation and Dilution of a Standard Solution - Lab I1 (Page I21)

1. In the prelab discussion, the following techniques should be reviewed:
   a. measuring out a particular mass of a substance
   b. use of graduated cylinders, volumetric flasks and reading of the meniscus
   c. use of pipets. Pipet bulbs are much more easily used by novices if they are reshaped (using a conical grinding tip in an electric drill) in the following way:



Bevelling the conical hole allows the bulb to be used with pipets of various diameters, makes the bulb easy to apply and remove, and affects a good seal between bulb and pipet.

2. It is unnecessary to prepare vials of $CuSO_4 \cdot 5H_2O$. Students can mass the required amount of $CuSO_4 \cdot 5H_2O$ from stock supplies.

3. Remind students that the water of hydration in $CuSO_4 \cdot 5H_2O$ must be considered in determining the molar mass.

4. Volumetric flasks and pipets are more accurate in the preparation of solutions, but graduated cylinders are adequate.

5. The concentration of the students' diluted solutions may be checked by:

   a. measuring the electrical conductivity with a calibrated ohmmeter (or multimeter)

   b. measuring the color intensity using a photometer

   c. comparing the color intensity of the students' solutions with the color intensity of three standard solutions of copper(II) sulfate solution set up in 100 ml graduated cylinders. Solutions of 0.0150M (0.39 g of $CuSO_4 \cdot 5H_2O$/100 ml solution), 0.0200M (0.52 g of $CuSO_4 \cdot 5H_2O$/100 ml solution) and 0.025M (0.65 g of $CuSO_4 \cdot 5H_2O$/100 ml solution) allow a 25% parameter of comparison. Setting up the graduated cylinders on white paper and looking vertically through the solutions helps in the color comparison.

Electrolytes and Nonelectrolytes - Demo I3 (Page I23)

1. The quantity of solute required to prepare the solutions to be tested is given below. These quantities are specified in grams per 100 ml of solution for pure solutes and in volume when required per litre of solution for the substances that have to be prepared by dilution from stock solutions.

   a. Mass of solute per 100 ml of solution

$NaC\ell$	0.58 g	$C_6H_{12}O_6$	1.81 g
CH_3OH	0.32 g	$Ca(OH)_2$	saturated solution
$NaOH$	0.40 g	I_2	saturated solution
NH_4CH_3COO	0.77 g	$CuSO_4 \cdot 5H_2O$	2.60 g
KOH	0.56 g	$KMnO_4$	1.58 g
C_4H_9OH	0.75 g	$(CH_3)_2CO$	0.57 g
$C_{12}H_{22}O_{11}$	3.42 g	$C_3H_5(OH)_3$	0.92 g
$K_2Cr_2O_7$	2.94 g	$NaHCO_3$	0.84 g

b. Volume of concentrated solute per 1.00 litre of solution

$HC\ell$	8.1 ml
H_2SO_4	5.7 ml
HNO_3	6.5 ml
CH_3COOH	5.8 ml
NH_4OH	6.8 ml

The Solubility of a Soluble Substance - Lab I2 (Page I34)

1. Na_2CO_3 is used in this experiment because its solubility changes markedly with changes in temperature.

2. The Na_2CO_3 will precipitate within the pipet if a cold pipet is used to transfer 10 ml of hot saturated solution. To overcome this problem the pipet must be somehow preheated. This might be done by warming the pipet in a stream of hot water from a water tap or by immersing the pipets in a pail of hot water.

3. The solution of Na_2CO_3 can be evaporated to dryness using a bunsen burner if a low flame is used to minimize spattering. A hot water or steam bath would be preferable.

4. Some changes to materials and procedure are required:

   a. evaporating dish is to be used instead of petri dish

   b. when evaporating Na_2CO_3 solution to dryness, cover evaporating dish with a watch glass. This will necessitate finding the initial mass of the evaporating dish and the watch glass. Also moisture may adhere to the watch glass during the drying process. This may require that the watch glass be dried separately by holding it above a burner flame using tongs.

TEACHERS' GUIDE

SOLUTIONS

Answer Key

Page I3: Preparation of a Solution--Demo I1

1. a. # mol $K_2Cr_2O_7$ = 0.00350 mol

2. b. mass $K_2Cr_2O_7$ = 1.03 g

Page I5: Concentration from Moles and Volume

1. 2.50 M
2. 0.500 M
3. 1.20 M
4. 0.250 M
5. 2.00 M

Page I6: Concentration from Mass and Volume

1. 0.0400 M
2. 5.00 M
3. 0.0178 M
4. 2.06 M

Page I7: Solution Problems

1. 0.001 78 M
2. 0.000 062 9 M
3. 0.000 021 9 M
4. 0.000 022 7 M
5. 0.000 007 04 M
6. 0.000 004 54 M
7. 0.000 005 55 M

Page I8: Moles from Volume and Concentration

1. 0.600 mol
2. 0.100 mol
3. 0.001 38 mol
4. 0.480 mol
5. 005 00 mol

Page I9: Mass from Volume and Concentration

1. 29.3 g
2. 0.926 g
3. 84.2 g
4. 1.43 g

Page I10: Volume from Moles and Concentration

1. 0.100 ℓ or 100 ml
2. 0.560 ℓ or 56.0 ml
3. 0.750 ℓ or 750 ml
4. 36.0 ℓ
5. dissolve to 1.50 ℓ

Page I11: Volume from Mass and Concentration

1. 2.00 ℓ
2. 1.25 ℓ
3. 0.325 ℓ 04 325 ml
4. dissolve to 2.00 ℓ

Pages I12 and I13: Solution Problems--An Overview

1. 0.800 M
2. 0.0112 mol
3. 0.80 ℓ
4. 0.499 M
5. 5.0 ℓ
6. 13.7 g
7. dissolve 102 g to 900 ml

SOLUTIONS

Answer Key -- Unit I

Pages I15, I16 and I17: Dilution Problems

1. 400 ml
2. 4.50 M
3. 1.60 ℓ
4. 187 ml
5. 42.5 ml
6. 2.59 M
7. 2.40×10^5 ℓ
8. 0.0300 M
9. 1.50×10^8 ℓ
10. 267 ml
11. 100 ml stock solution; 500 ml H_2O
12. 0.0600 M
13. 0.0320 M
14. 80.0 ml of 0.750 M and 40.0 ml of 3.00 M

Page I22: Preparation of a Standard Solution and Dilution of Known Solution Calculations

1. a. 0.0200 mol
   b. 5.20 g
3. 0.0200 M

Questions

1. Color intensity changes noticeably upon dilution

2. The more concentrated solution would react with zinc at a faster rate because there would be more frequent collisions between reactant species at higher temperatures.

3. # mol of concentrated solution = $\frac{0.200 \text{ mol}}{\ell} \times 0.008\,00 = 0.001\,60$ mol

   # mol of diluted solution = $\frac{0.0200 \text{ mol}}{\ell} \times 0.0400 = 0.000\,800$ mol

   The concentrated solution would react with more zinc metal

Page I23: Electrolytes and Nonelectrolytes

Questions

1. Ionic compounds and acids were electrolytes
   Molecular compounds were nonelectrolytes

2. Electrolytes upon dissolving dissociate to form ions and hence conducting solution. Nonelectrolytes retain their molecular identity upon dissolving.

Page I25: Dissociation Equations

1. $KOH_{(s)} \longrightarrow K^{1+}_{(aq)} + OH^{1-}_{(aq)}$

2. $Na_2CO_{3(s)} \longrightarrow 2Na^{1+}_{(aq)} + CO^{2-}_{(aq)}$

3. $KMnO_{4(s)} \longrightarrow K^{1+}_{(aq)} + MnO^{1-}_{(aq)}$

4. $HCl_{(g)} \longrightarrow H^{1+}_{(aq)} + Cl^{1-}_{(aq)}$

5. $(NH_4)_2SO_{4(s)} \longrightarrow 2NH^{1+}_{4(aq)} + SO^{2-}_{4(aq)}$

6. $Ga_2(CO_3)_{3(s)} \longrightarrow 2Ga^{3+}_{(aq)} + 3CO^{2-}_{3(aq)}$

Answer Key--Unit I

Page I25 :

7. $Al_2(SO_4)_{3(s)} \longrightarrow 2Al^{3+}_{(aq)} + 3SO_{4\,(aq)}^{2-}$

8. $NaHCO_{3(s)} \longrightarrow Na^{1+}_{(aq)} + HCO_{3\,(aq)}^{1-}$

9. $KNO_{3(s)} \longrightarrow K^{+}_{(aq)} + NO_{3\,(aq)}^{1-}$

10. $Mg(OH)_{2(s)} \longrightarrow Mg^{2+}_{(aq)} + 2OH^{1-}_{(aq)}$

11. $AgNO_{3(s)} \longrightarrow Ag^{1+}_{(aq)} + NO_{3\,(aq)}^{1-}$

12. $Cu(NO_3)_{2(s)} \longrightarrow Cu^{2+}_{(aq)} + 2NO_{3\,(aq)}^{1-}$

13. $Pb(NO_3)_{2(s)} \longrightarrow Pb^{2+}_{(aq)} + 2NO_{3\,(aq)}^{1-}$

14. $KI_{(s)} \longrightarrow K^{1+}_{(aq)} + I^{1-}_{(aq)}$

15. $Al(ClO_3)_{3(s)} \longrightarrow Al^{3+}_{(aq)} + 3ClO_{3\,(aq)}^{1-}$

Pages I27 and I28: Concentration of Ionic Species

2. a. $Na_2SO_{4(s)} \longrightarrow 2Na^{1+}_{(aq)} + SO_{4\,(aq)}^{2-}$

0.28 M 0.14 M

b. $HCl_{(g)} \longrightarrow H^{1+}_{(aq)} + Cl^{1-}_{(aq)}$

6.0 M 6.0 M

c. $(NH_4)_2CO_{3(s)} \longrightarrow 2NH_{4\,(aq)}^{1+} + CO_{3\,(aq)}^{2-}$

5.0 M 2.5 M

d. $FeCl_{3(s)} \longrightarrow Fe^{3+}_{(aq)} + 3Cl^{-}_{(aq)}$

0.264 M 0.792 M

e. $K_3PO_{4(s)} \longrightarrow 3K^{1+}_{(aq)} + PO_{4\,(aq)}^{3-}$

0.26 M 0.087 M

f. $Al_2(SO_4)_{3(s)} \longrightarrow 2Al^{3+}_{(aq)} + 3SO_{4\,(aq)}^{2-}$

0.252 M 0.378 M

Answer Key--Unit I

Page I29: Concentration of Ionic Species

g. $Ba(CH_3COO)_{2(s)} \longrightarrow Ba^{2+}_{(aq)} + 2CH_3COO^{1-}_{(aq)}$
0.329 M 0.658 M

h. $K_2CO_{3(s)} \longrightarrow 2K^{1+}_{(aq)} + CO^{2-}_{3(aq)}$
3.2 M 1.6 M

i. $Li_2S_{(s)} \longrightarrow 2Li^{1+}_{(aq)} + S^{2-}_{(aq)}$
1.70 M 0.85 M

j. $NaOH_{(s)} \longrightarrow Na^{1+}_{(aq)} + OH^{1-}_{(aq)}$
0.500 M 0.500 M

k. $K_2CrO_{4(s)} \longrightarrow 2K^{1+}_{(aq)} + CrO^{1-}_{(aq)}$
0.666 M 0.333 M

l. $Na_2CO_{3(s)} \longrightarrow 2Na^{1+}_{(aq)} + CO^{2-}_{3(aq)}$
53.0 g

m. $(NH_4)_2SO_{4(s)} \longrightarrow 2NH^{1+}_{(aq)} + SO^{2-}_{4(aq)}$
15.9 g

n. $K_2Cr_2O_{7(s)} \longrightarrow 2K^{1+}_{(aq)} + Cr_2O^{1-}_{7(aq)}$
88.3 g

o. $AlClO_{3(s)} \longrightarrow Al^{3+}_{(aq)} + 3ClO^{1-}_{3(aq)}$
21.2 g

p. $Rb_2SO_{4(s)} \longrightarrow 2Rb^{1+}_{(aq)} + SO^{2-}_{4(aq)}$
13.4 g

Page I32: Exercises on Solubility

1. 10.8 M
2. 4.65 M
3. 0.650 g
4. 85.5 cubes

Page I34: The Solubility of A Soluble Substance - Lab I2

The solubility of Na_2CO_3: 7.1 g/ℓ at 0°C
45.5 g/ℓ at 100°C

Questions:

1. Solubility refers to the concentration of a solution at saturation.
2. The molar solubility of Na_2CO_3 increases with temperature.
4. Molar solubility gives the concentration at saturation in moles per unit volume and so represents the concentration at saturation of a solution of any volume.

TEACHERS' GUIDE

REACTIONS IN SOLUTION

General Information

1. This unit is quite lab-oriented. Demonstration of lab techniques is strongly recommended. The labs have been selected for stoichiometric accuracy, simplicity and common availability of reagents and apparatus.

2. Students should be readily able to identify precipitation reactions since a solubility chart is included on the ALCHEM periodic table.

3. Teachers may find it necessary to prepare additional exercises on ionic equations since this is one concept with which students generally experience difficulty.

4. It is important that students learn to distinguish between reactions with water and dissociation in water. The difficulty occurs where students do not understand when water should be written as a reactant and when water behaves only as a dissociating or ionizing solvent. For example, when Ca is added to water, water is shown as a reactant in the equation for the reaction. On the other hand, when an ionic compound such as $NaC\ell$ is added to water, the water is not shown as a reactant in the resulting dissociation equation. It is advisable that students be given additional drill exercises to reinforce the concept of reaction with water and/or dissociation in water.

Reactions in Solution - Demo J1

1. Note that students are asked to identify three reaction types in solution. Double replacement reactions are to be identified either as precipitation or neutralization reactions.

2. It is suggested that the solutions to be used are prepared in 1M concentrations.

3. Additional materials that will be required for steps 5 and 7:

   a. dropper bottle of $CC\ell_4$
   b. chlorine water in dropper bottle
   c. Br_2 and I_2 solutions in dropper bottles made by dissolving Br_2 and I_2 in a 50-50% water-alcohol mixture.

4. For steps 5 and 7:

   a. Procedure 5: chlorine and sodium bromide
   Demonstrate the colour of Br_2 in $CC\ell_4$ phase, then add $CC\ell_4$ to the NaBr(aq) before adding chlorine water

   b. Procedure 7: bromine and potassium iodide
   Demonstrate the colour of I_2 in $CC\ell_4$ phase, then add $CC\ell_4$ to the KI(aq) before adding bromine solution

5. In step 10, the reaction initially forms a blue precipitate of chromium (III) hydroxide. If left standing the chromium (III) hydroxide changes to chromium (I hydroxide which is green in colour and soluble.

TEACHERS' GUIDE

REACTIONS IN SOLUTION

Reactions in Solution - Lab J1 (Page J11)

1. This lab is designed to be completed in two days.

2. It is not mentioned in the procedure for Day 1, part 1, but the zinc strip should be cleaned with steel wool and then wiped clean before finding its initial mass.

3. Each part of this lab involves four unknown solutions differing only in concentration. Divide the class into four parts, each part to be assigned one of the solutions.

4. During post lab discussion recopy the group data tables onto the blackboard, or overhead transparency, to enable students to fill in the group data tables in their notes.

5. Solutions are numbered consecutively to avoid confusion. Concentrations of these solutions should not be given on the labelled solutions.

6. Preparations:

Part I:

a. Prepare four $CuSO_4$ solutions as outlined below:

Solution 1	0.10 M
Solution 2	0.15 M
Solution 3	0.05 M
Solution 4	0.20 M

b. These should give mass losses from 0.40 grams to 1.40 grams for the zinc strips reacted with these solutions.

c. A class of 15 groups will require about 1.5 litres of each solution.

Part II:

a. Prepare about 300 ml of 1.00 M Na_2SO_4 solution for each class.

b. Prepare about 100 ml of each of the following solutions of $BaCl_2$ for each class.

Solution 5	0.80 M
Solution 6	0.40 M
Solution 7	0.20 M
Solution 8	0.60 M

Part III:

a. Prepare about 500 ml of 0.100 M HCl for each class.

b. Prepare about 1 litre of each of the following solutions of NaOH for each class.

Solution 9	0.050 M
Solution 10	0.15 M
Solution 11	0.10 M
Solution 12	0.20 M

TEACHERS' GUIDE

REACTIONS IN SOLUTION

A Single Replacement Reaction in Solution - Demo J2 (Page J16)

1. The demonstration of a reaction between a zinc strip and an aqueous solution of copper(II) sulfate is useful if done over a 3 day period during the introduction of solution stoichiometry. It provides an example of correct laboratory techniques and calculation procedures.

2. Zn strip 1 mm thick is available from most chemical supply houses. Cut into pieces of 10 - 15 g each.

3. Make the copper(II) sulfate solution by dissolving about 9 - 11 g of solid $CuSO_4 \cdot 5H_2O$ in 200 ml of water.

4. The following is a list of materials needed for this demonstration:

    1 - Zn strip
    - about 200 ml of copper(II) sulfate solution labelled unknown concentration (see Number 3 above)
    1 - reagent bottle of 6 M $HC\ell$
    1 - 400 ml beaker
    1 - 250 ml beaker
    1 - filter funnel
    1 - filter paper
    1 - ring stand
    1 - funnel holder
    1 - centigram balance
    1 - stirring rod
    1 - wash bottle containing distilled H_2O
    1 - 100 ml graduated cylinder

TEACHERS' GUIDE

TITRATION

Titration - Demo J3 (Page J28)

1. Because of the many special techniques involved in a titration, this demonstration is suggested before the students go to the laboratory.

2. Teachers may wish to point out to students that their titration techniques may be evaluated during the actual titration lab. A space is provided for teacher comments in the student lab notes.

3. If more than 10.0 ml of base is titrated three significant digits are achieved by reading the buret to 0.1 ml.

4. Additional titration steps such as standardizing, cleaning burets and using different indicators will be introduced in the Chemistry 30 course. Other aspects of titration including titration curves and redox titrations are also covered in the Chemistry 30 course.

5. Point out to the students that titrations are not always neutralization reactions. Students will be doing redox titrations in Chemistry 30.

6. The following demo kit for each chemistry classroom is required:

   1 - buret
   1 - buret clamp
   1 - ring stand
   1 - short stem funnel
   1 - meniscus finder
   1 - 10 ml pipet
   1 - pipet bulb (honed)
   1 - 250 ml Erlenmeyer flask
   1 - 400 ml beaker (marked Waste)
   1 - 100 ml beaker (marked Base)
   1 - 50 ml beaker (marked Acid)
   1 - dropper bottle of phenolphthalein
   1 - wash bottle with distilled water
   1 - stoppered flask of 0.200 M H_2SO_4
   1 - stoppered flask of 0.300 M NaOH
   (labelled ? M NaOH)

TEACHERS' GUIDE

TITRATION

Titration - Lab J2

1. The titration lab has been developed as a first exposure to titration. The student will again do a titration lab in ALCHEM 30 where additional aspects of titration may be introduced.

   For example:

   a. an acid or base could be standardized as an initial step.
   b. Burets could be cleaned properly.
   c. different indicators could be used.

2. A demonstration titration such as provided on an earlier page should precede the titration lab. Proper laboratory techniques are pictured in the demonstration notes.

3. The students will assume in their calculations that the 0.0300 M H_2SO_4 is accurate to the significant digits indicated. Unless both solutions can be made accurate to three significant digits, the lab assistant or teacher should do three titrations to determine the concentration of the NaOH(aq).

4. Since students have probably completed a number of neutralization and titration type problems previously, the emphasis in this lab should be placed on titration techniques and sources of error. To this end a space for teacher comments on technique has been provided at the end of the student lab notes.

5. In the pop titration, instead of students pipetting the pop, have them use graduated cylinders since the pop's effervescence makes pipetting impractical. Also have students use *20 mℓ of pop* so that a volume of NaOH greater than 10.0 ml would be used in the titration.

6. Recopy the group data table from Day 2 on the blackboard or an overhead transparency and fill it in as a class discussion activity.

7. The required materials are listed in the students materials.

   a. Meniscus finders can either be made by the students or made from stiff paper by the lab assistant.
   b. The burets should be washed, rinsed and inverted in the buret clamp before the first class comes to the laboratory. Students will not have time to scrub their burets with a buret brush.
   c. Pipet bulbs should be honed as described for a previous lab.

8. The total maximum volumes of solution required assuming three titrations on Day 1 and three titrations on Day 2 are:

   a. 1.5ℓ 0.0300M H_2SO_4 per class (1.70 ml concentrated 17.6M H_2SO_4/ℓ).

   b. 3.0ℓ 0.0500M NaOH per class (2.00g NaOH/ℓ).

   c. 250 ml of each brand of diluted vinegar per class (25 ml of each brand of commercial vinegar per class).

   d. 500 ml of each brand of pop per class (one half large bottle of each brand of pop per class).

   e. 500 ml of each brand of diluted household ammonia per class (25 ml of each brand of ammonia per class).

9. The solutions to be prepared for Day 2 are listed below. Each group is to do only one vinegar, one pop and one ammonia titration.

   a. Vinegar Titration

      i. 0.0500 M NaOH from Day 1 - maximum of 100 ml/group or 1500 ml/class.

      ii. Dilute the commercial vinegar 10 fold (from approximately 1M to 0.1M) - maximum of 50 ml/group or 250 ml/class of each brand. Buy three brands and label the stock bottles with the brand names.

   b. Pop Titration

      i. 0.0500 M NaOH from Day 1 - maximum of 100 ml/group or 1500 ml/class. If the pop titration and the vinegar titration are done consecutively, no additional NaOH is required.

      ii. Use undiluted pop - maximum 100 ml/group or 500 ml/class (one half of large bottle) of each brand. If the pop is kept cold the amount of fizzing will be minimized. Buy three brands of pop which are colourless enough so as not to mask the endpoint.

   c. Household Ammonia Titration

      i. 0.0300 M H_2SO_4 from Day 1 - maximum of 50 ml/group or 750 ml/class.

      ii. Dilute the commercial household ammonia 20 fold (from approximately 1.5 M to 0.075M) - maximum 100 ml/group or 500 ml/class of each brand. Buy three brands and label the stock bottle with the brand name.

10. The total volumes of the solutions would best be prepared or mixed in a large plastic container with a top. Buy the plastic container from housewares or camping goods at a local store.

11. In order to facilitate classroom discussion the cost per litre of household ammonia might be written on the ammonia stock bottles.

Determination of the Unknown Concentration of a Solution by Gravimetric Analysis - Lab J3 (Page J35)

1. The lab procedure assumes that the teacher has demonstrated proper techniques for
   a. pipetting
   b. filtering

2. The amounts of reagents required are as follows:

   a. 0.0500 M $Pb(NO_3)_2$, 16.56 g/ℓ. A class of 20 groups will require approximately 3 litres.
   b. 0.125 M KIO_3, 26.75 g/ℓ. A class of 20 groups will require approximately 3 litres.

3. Distilled water is essential for clear solutions. Use of tap water will precipitate $PbC\ell_2$.

4. If variety in unknowns is desired, the original $Pb(NO_3)_2$ solution could be diluted to give a variety of concentrations. Do not dilute to less than 0.200 M in order to have sufficient precipitate.

5. To promote rapid filtering, the following are recommended:

   a. use filter paper of 12 cm diameter or larger
   b. use qualitative grade filter paper
   c. emphasize use of small amounts (about 5ml portions) of water in rinsing and washing.

TEACHERS' GUIDE

REACTIONS IN SOLUTION

Answer Key--Unit J

Pages J3 and J4: Reactions in Solution - Demo J1

1. Single replacement

$$Zn_{(s)} + H_2SO_{4(aq)} \longrightarrow H_{2(g)} + ZnSO_{4(aq)}$$

2. Double replacement (Precipitation)

$$Pb(NO_3)_{2(aq)} + 2KI \longrightarrow PbI_{2(s)} + 2KNO_{3(aq)}$$

3. Single replacement

$$Ca_{(s)} + 2HOH \longrightarrow H_{2(g)} + Ca(OH)_{2(aq)}$$

4. Double replacement (Neutralization)

$$HCl_{(aq)} + KOH_{(aq)} \longrightarrow KCl_{(aq)} + HOH$$

5. Single replacement

$$Cl_{2(aq)} + 2NaBr_{(aq)} \longrightarrow 2NaCl_{(aq)} + Br_{2(CCl_4)}$$

6. Double replacement (Neutralization and Precipitation)

$$Ba(OH)\ _{(aq)} + H_2SO_{4(aq)} \longrightarrow BaSO_{4(s)} + 2HOH$$

7. Single replacement

$$Br_{2(aq)} + 2KI_{(aq)} \longrightarrow 2KBr_{(aq)} + I_{2(CCl_4)}$$

8. Double replacement (Precipitation)

$$Pb(NO_3)_{2(aq)} + 2NaBr_{(aq)} \longrightarrow PbBr_{2(s)} + 2NaNO_{3(aq)}$$

9. Double replacement (Neutralization)

$$CH_3COOH_{(aq)} + NaOH_{(aq)} \longrightarrow NaCH_3COO_{(aq)} + HOH$$

10. Double replacement (Precipitation)

$$Cr(NO_3)_{3(aq)} + 3NaOH_{(aq)} \longrightarrow Cr(OH)_{3(s)} + 3NaNO_{3(aq)}$$

Page J5: Reactions in Solution

A. 1. $$\underset{\text{acid}}{HCl_{(aq)}} + \underset{\text{base}}{KOH_{(aq)}} \longrightarrow \underset{\text{water}}{HOH} + \underset{\text{salt}}{KCl_{(aq)}}$$

2. $$BaCl_{2(aq)} + Na_2SO_{4(aq)} \longrightarrow BaSO_{4(s)} + 2NaCl_{(aq)}$$

Answer Key--Unit J

Page J5: Reactions in Solution

3. $2NH_4Cl_{(aq)} + Pb(CH_3COO)_{2(aq)} \longrightarrow 2NH_4CH_3COO_{(aq)} + PbCl_{2(s)}$

4. $\underset{\text{base}}{LiOH_{(aq)}} + \underset{\text{acid}}{H_2SO_{4(aq)}} \longrightarrow \underset{\text{salt}}{Li_2SO_{4(aq)}} + \underset{\text{water}}{2HOH}$

5. $\underset{\text{acid}}{H_2SO_{3(aq)}} + \underset{\text{base}}{2NaOH_{(aq)}} \longrightarrow \underset{\text{water}}{2HOH} + \underset{\text{salt}}{2Na_2SO_{3(aq)}}$

6. $2AgNO_{(aq)} + Li_2CO_{3(aq)} \longrightarrow Ag_2CO_{3(s)} + 2LiNO_{3(aq)}$

7. $RbI + HgNO_{3(aq)} \longrightarrow RbNO_{3(aq)} + HgI_{(s)}$

8. $\underset{\text{base}}{Ca(OH)_{2(aq)}} + \underset{\text{acid}}{2HNO_{3(aq)}} \longrightarrow \underset{\text{salt}}{Ca(NO_3)_{2(aq)}} + \underset{\text{water}}{2HOH}$

9. $3Ca(OH)_{2(aq)} + 2Na_3PO_{4(aq)} \longrightarrow Ca_3(PO_4)_{2(s)} + 6NaOH_{(aq)}$

10. $\underset{\text{acid}}{2H_3PO_{4(aq)}} + \underset{\text{base}}{3Mg(OH)_{2(aq)}} \longrightarrow \underset{\text{water}}{6HOH} + \underset{\text{salt}}{Mg_3(PO_4)_{2(aq)}}$

B.

1. $Ca(HCO_3)_{2(aq)} + Ca(OH)_{2(aq)} \longrightarrow 2CaCO_{3(s)} + 2HOH$

2. $Mg(HCO_3)_{2(aq)} + Ca(OH)_{2(aq)} \longrightarrow Mg(OH)_{2(s)} + 2HOH$

3. $CaSO_{4(aq)} + Na_2CO_{3(aq)} \longrightarrow CaCO_{3(s)} + Na_2SO_{4(aq)}$

4. $MgSO_{4(aq)} + Ca(OH)_{2(aq)} \longrightarrow Mg(OH)_{2(s)} + CaSO_{4(aq)}$

Page J6: Reactions in Solution

C. Any soluble cupric compound + any soluble sulfide compound

Example: $Cu(NO_3)_{2(aq)} + K_2S_{(aq)} \longrightarrow CuS_{(s)} + 2KNO_{3(aq)}$

D. Any soluble barium compound + any soluble phosphate compound

Example: $3Ba(OH)_{2(aq)} + 2H_3PO_{4(aq)} \longrightarrow Ba_3(PO_4)_{2(s)} + 6HOH$

E. BaS by precipitation

Example: $Ba(NO_3)_{2(aq)} + K_2S_{(aq)} \longrightarrow BaS_{(s)} + 2KNO_{3(aq)}$

BaS by neutralization

Example: $Ba(OH)_{2(aq)} + H_2S_{(aq)} \longrightarrow BaS_{(s)} + 2HOH$

TEACHERS' GUIDE

REACTIONS IN SOLUTION

Additonal General Information

Some inconsistency arises as a result of the present consideration that acids are electrolytes which undergo dissociation, and later consideration of acids in *ALCHEM 30*, Unit N, that acids are electrolytes which react chemically with water to form ions. This, inconsistency may lead to the following misconceptions by students.

1. Representation for acid.

   Present representation for the hydrogen ion as $H^+_{(aq)}$ opposed to the representation in *ALCHEM 30* as the hydronium ion, $H_3O^+_{(aq)}$. This should not pose any major problem since both representations are correct.

2. Dissociation of weak and polyprotic acids.

   Present consideration may induce students to believe that all acids undergo complete dossociation. For the present, teachers may avoid such misconceptions by restricting their consideration to monoprotic strong acids and *avoiding* the writing of dissociation equations for polyprotic acis as follows:

   $$H_2SO_{4(\ell)} \longrightarrow 2H^+_{(aq)} + SO_4^-{}_{(aq)}$$

   It is planned that future revisions will avoid this difficulty by omitting consideration of the ionization of acids in *ALCHEM 20*.

As well, to avoid unnecessary confusion, instruct students to use nonionic equations for solving solution stoichiometry problems. This, also, applies to titration problems.

Answer Key--Unit J

Pages J9 and J10: Net Ionic Equations

1. total ionic: $2Na_{(s)} + 2HOH \longrightarrow 2Na^{+}_{(aq)} + 2OH^{-}_{(aq)} + H_{2(g)}$
   net ionic: same
2. total ionic: $Pb^{2+}_{(aq)} + 2NO_{3}^{-}{}_{(aq)} + H_{2}S_{(g)} \longrightarrow PbS_{(s)} + 2H^{+}_{(aq)} + 2NO_{3}^{-}{}_{(aq)}$
   net ionic: $Pb^{2+}_{(aq)} + H_{2}S_{(g)} \longrightarrow PbS_{(s)} + 2H^{+}_{(aq)}$
3. total ionic: $H^{1+}_{(aq)} + ClO_{3}^{1-}{}_{(aq)} + K^{1+}_{(aq)} + OH^{1-}_{(aq)} \longrightarrow K^{1+}{}_{(aq)} + ClO_{3}{}^{1-}{}_{(aq)} + HOH$
   net ionic: $H^{1+}_{(aq)} + OH^{1-}_{(aq)} \longrightarrow HOH$
4. total ionic: $2H^{1+}_{(aq)} + 2Cl^{1-}_{(aq)} + Ba^{2+}_{(aq)} + 2OH^{1-}_{(aq)} \longrightarrow Ba^{2+}_{(aq)} + 2Cl^{1-}_{(aq)} + 2HOH$
   net ionic: $2H^{1+}_{(aq)} + 2OH^{1-}_{(aq)} \longrightarrow 2HOH$
5. total ionic: $Mg_{(s)} + 2H^{1+}_{(aq)} + 2Br^{1-}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + 2Br^{1-}_{(aq)} + H_{2(g)}$
   net ionic: $Mg_{(s)} + 2H^{1+}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + H_{2(g)}$
6. total ionic: $Ca_{(s)} + 2HOH_{(\ell)} \longrightarrow Ca^{2+}_{(aq)} + 2OH^{1-}_{(aq)} + H_{2(g)}$
   net ionic: same
7. total ionic: $2H^{1+}_{(aq)} + 2Cl^{1-}_{(aq)} + CaCO_{3(s)} \longrightarrow Ca^{2+}_{(aq)} + 2Cl^{1-}_{(aq)} + H_{2}O + CO_{2(g)}$
   net ionic: $2H^{1+}_{(aq)} + CaCO_{3(s)} \longrightarrow Ca^{2+}_{(aq)} + H_{2}O + CO_{2(g)}$
8. total ionic: $2Na^{1+}_{(aq)} + SO_{4}^{2-}{}_{(aq)} + Ba^{2+}_{(aq)} + Br^{1-}_{(aq)} \longrightarrow BaSO_{4(s)} + 2Na^{1+}_{(aq)} + 2Br^{1-}_{(aq)}$
   net ionic: $Ba^{2+}_{(aq)} + SO_{4}^{2-}{}_{(aq)} \longrightarrow BaSO_{4(s)}$
9. total ionic: $2Na^{1+}_{(aq)} + CO_{3}^{2-}{}_{(aq)} + Ca^{2+}_{(aq)} + SO_{4}^{2-}{}_{(aq)} \longrightarrow CaCO_{3(s)} + 2Na^{1+}_{(aq)} + SO_{4}^{2-}{}_{(aq)}$
   net ionic: $Ca^{2+}_{(aq)} + CO_{3}^{2-}{}_{aq)} \longrightarrow CaCO_{3(s)}$
10. total ionic: $Mg^{2+}_{(aq)} + 2OH^{-}_{(aq)} + 2H^{+}_{(aq)} + 2NO_{3}^{1-}{}_{(aq)} \longrightarrow Mg^{2+}_{(aq)} + 2NO_{3}^{1-}{}_{(aq)} + 2HOH$
    net ionic: $2OH^{-}_{(ag)} + 2H^{1+}_{(aq)} \longrightarrow 2HOH$

Page J13: Reactions in Solutions - Lab J1

Questions--Part I

1. The concentration of the $CuSO_4$ solution varied.

3. The initial solution may have differed in intensity of blue color.

Answer Key--Unit J

Page J13: Reactions in Solutions--Lab J1

4. $Cu^{2+}_{(aq)} + SO^{2-}_{4(aq)} + Zn_{(s)} \longrightarrow Cu_{(s)} + SO^{2-}_{4(aq)} + Zn_{(s)}$ or

   $Cu^{2+}_{(aq)} + Zn_{(s)} \longrightarrow Cu_{(s)} + Zn^{2+}_{(aq)}$

Page J14: Reactions in Solution - Lab J1

Questions--Part II

1. The concentration of the $BaCl_2$ solution varied.

3. The initial solutions of $BaCl_2$ are identical in appearance.

4. $Ba^{2+}_{(aq)} + 2Cl^{-}_{(aq)} + 2Na^{1+}_{(aq)} + SO^{2-}_{4(aq)} \longrightarrow BaSO_{4(s)} + 2Na^{1+}_{(aq)} + 2Cl^{1-}_{(aq)}$, or
   $Ba^{2+}_{(aq)} + SO^{2-}_{4(aq)} \longrightarrow BaSO_{4(s)}$

Page J15: Reactions in Solution - Lab J1

Questions--Part III

1. The concentration of the HCl solution varied.

2. The initial solutions of HCl are identical in appearance

3. $Na^{1+}_{(aq)} + OH^{1-}_{(aq)} + H^{1+}_{(aq)} + Cl^{1-}_{(aq)} \longrightarrow Na^{1+}_{(aq)} + Cl^{1-}_{(aq)} + HOH$, or
   $OH^{1-}_{(aq)} + H^{1+}_{(aq)} \longrightarrow HOH$.

Pages J17 and J18: A single Replacement Reaction in Solution - Demo J2

Calculations and Questions

1. $Zn_{(s)} + Cu^{2+}_{(aq)} + SO^{2-}_{4(aq)} \longrightarrow Zn^{2+}_{(aq)} + SO^{2-}_{4(aq)} + Cu_{(s)}$, or
   $Zn_{(s)} + Cu^{2+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + Cu_{(s)}$

6. Some Zn reacted with the $HCl_{(aq)}$ that was added to loosen the copper particles from the Zn strip.

7. $Zn_{(s)} + 2H^{1+}_{(aq)} + 2Cl^{1-}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + H_{2(g)} + 2Cl^{1-}_{(aq)}$, or
   $Zn_{(s)} + 2H^{1+}_{(aq)} \longrightarrow Zn^{2+}_{(aq)} + H_{2(g)}$

NOTE: It will simplify matters if students use nonionic equations for stoichiometry problems.

Pages J22 & J23: Solution Stoichiometry

1. 0.0667 M
2. 40.0 ml
3. 12.0 ml
4. 5.28 M
5. 0.000 040 M
6. 0.200 M

TEACHERS' GUIDE

REACTIONS IN SOLUTION

Answer Key--Unit J

Pages J24 and J25: Gravimetric and Solution Stoichiometry

1. 0.794 g
2. 15.0 ml
3. 0.600 M
4. 0.480 M
5. 1.02 kg
6. 0.0180 mol

Pages J26 and J27: Solution Stoichiometry--An Overview

1. 2.16 M
2. 3.00 ml
3. 38.1 g
4. 0.160 M
5. 1.7 ℓ
6. 0.516 M

Page J33: Titration--Lab J2

The Composition of Household Ammonia

The Federal Department of Consumer and Corporate Affairs indicated that since household ammonia is not considered as a food or drug, there are no standards as to the amount of $NH_{(g)}$ dissolved in household ammonia. However their sources of information indicate that household ammonia is usually 5-10% weight by volume; i.e., 5 g/100 ml to 10 g/100 ml. In terms of molar concentration, this would indicate a range of 2.94 M to 5.88 M (roughly 3-6 M) concentration of $NH_3(g)$ in household ammonia.

The Composition of Vinegar

The Federal Department of Consumer and Corporate Affairs indicated that according to Food and Drug Standards, vinegar should be not less than 4.1% and not more than 12.3% weight by volume; i.e., from 4.1 g/100 ml to 12.3 g/100 ml. Their sources of information also indicate in practise vinegar is 4-6% weight by volume. According to this latter standard it could be expected that the molar concentration of vinegar is generally between 0.677 M and 1.00 M acetic acid.

Page J34: Titration Problems

1. 0.140 M
2. 0.107 M
3. 1.77 M

Pages J36 and J37: The Determination of the Unknown Concentration of a Solution by Gravimetric Analysis--Lab J3

Calculations and Questions

1. $Pb^{2+}_{(aq)} + 2NO_3{}^{1-}_{(aq)} + 2K^{1+}_{(aq)} + 2IO_3{}^{1-}_{(aq)} \longrightarrow Pb(IO_3)_{2(s)} + 2NO_3{}^{1-}_{(aq)}$, or

$$Pb^{2+}_{(aq)} + 2IO_3{}^{1-}_{(aq)} \longrightarrow Pb(IO_3)_{2(s)}$$

6. The availability of $Pb(NO_3)_2$ limits the amount of precipitate formed.
7. The mass of precipitate cannot be predicted from the number of moles of KIO_3 present initially because an excess amount of KIO_3 was used.
8. Ions present in the filtrate are $K^{1+}_{(aq)}$ and $NO_3{}^{1-}_{(aq)}$.

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